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ART. VIII.—*Notice of Julius Thomsen's Thermochemical Investigation of the Molecular Structure of the Hydrocarbon Compounds;** by JOSIAH P. COOKE.

THE value called in thermo-chemistry the heat of formation of a chemical compound is simply the sum of the calorific effects—both positive and negative—of the several processes, by which the compound may be formed from the elementary substances of which it consists. According to a fundamental theorem of thermotics this sum is always the same, by whatever series of processes the compound may be obtained, and may be regarded therefore as representing the amount of heat, which would be evolved by the direct union of the elementary substances, even when the given compound cannot be formed in that way. For convenience of calculation the results are usually stated not for the same weight of each compound, but for its equivalent or molecular weight. Thus when the heat of formation of sulphuric acid (H_2SO_4) is given as 193,000^c it is to be understood that 32 grams of solid sulphur, 64 grams of oxygen gas, and 2 grams of hydrogen gas (both gases taken in their ordinary state under the normal conditions of temperature and pressure), when united to form 98 grams of sulphuric acid, evolve sufficient heat to raise the temperature of 193,000 grams of water one degree. It must be noticed that our experiments only prove that in passing from the elementary substances to the ultimate product through the intermediate stages, which the production of sulphuric acid

* Berichte der deutsch. chem. Gesellschaft, xiii, 1880, pp. 1321, 1388, 1806.

involves, a certain amount of heat is lost on balancing the account. The further conclusion that the ultimate loss of heat is precisely the same as it would be if sulphuric acid could be made by the direct union of its elements, is an inference from the general theorem to which we have referred, and which may be stated thus:

Whenever a system of bodies undergoes chemical or physical changes and passes into another condition, whatever may have been the nature or succession of the changes the quantity of heat evolved or absorbed depends solely on the initial and final conditions of the system provided no effect has been produced on the bodies outside.

Hence when the initial and final conditions are the same, the total thermal effect is the same, however different the processes by which the result may be reached. These processes are physical as well as chemical. Thus in the production of sulphuric acid not only has a solid been rendered fluid but also two highly elastic gases have been condensed to the liquid state, changes, which, as is well known, must involve large calorific effects. Were it possible to eliminate the effects of such physical changes, we might hope to determine the amount of heat evolved in the chemical changes alone, and this would give us what we have so long sought, a measure of the forces which determine the union of the elementary atoms. We might then be able to find the amount of heat which would be evolved by the union of 32 grams of isolated sulphur atoms, 64 grams of isolated oxygen atoms, and 2 grams of isolated hydrogen atoms, to form 98 grams of isolated molecules of sulphuric acid. The comparison of such data would give us what we may appropriately call the thermal potentials of the isolated atoms in their several relations, and this would furnish a measure of the various bonds by which the atoms are held in combination, and afford a new and direct method of investigating molecular structures. We should thus obtain a certain criterion for determining the order and the nature of the bonds by which the atoms are united in any molecule. In a recent notice (this Journal, vol. xix, 264, April, 1880), we wrote: "The problem of finding what we have called the thermal potential of the atoms is not more remote than many problems which have been successfully solved in organic synthesis," and we have thus soon the pleasure of calling attention to a partial solution of the problem then stated.

As is well known, in the molecules $C\equiv C$; $HC\equiv CH$; $H_2C=CH_2$; H_3C-CH_3; H_4C | CH_4 (the first representing an assumed molecule of carbon in an aeriform condition, and the last representing two molecules of marsh gas) our present theories regard the two carbon atoms as united by four, three, two, one and no bonds respectively; and in the paper we are noticing Thomsen

seeks to determine the thermal value of these several bonds which he represents by the symbols v_4, v_3, v_2 and v_1.

As a starting point for the investigation he has redetermined experimentally the heat of combustion of several of the hydrocarbons, namely Methan CH_4, Ethan C_2H_6, Propan C_3H_8, Propylen C_3H_6, and the values obtained, together with the corresponding values for Ethylene C_2H_4 and Acetylene C_2H_2, previously determined (Pogg. Ann., v. 148, 390), are united in the column under I in the following table. Under column II of the same table we have given the heat of formation of the same hydrocarbons assumed to be produced from amorphous carbon and hydrogen gas. As we already know (from the experiments of Favre and Silbermann and from previous experiments of Thomsen), the heat of combustion both of amorphous carbon and of hydrogen gas, namely,

$$(C, O_2)=96{,}960^c \qquad (H_2, O)=68{,}360^c$$

it is very easy to calculate the values in column II from those in column I; for by a well-known principle of thermo-chemistry the heat of formation of a hydrocarbon is equal to the difference between the heat of combustion of the compound and sum of the similar values for the charcoal and hydrogen gas from which it is assumed to be formed. In the case of CH_4,

$$20{,}150^c=96{,}960^c+2\times 68{,}360^c-213{,}530^c.$$

We here assume that the hydrocarbon used in our experiments has the volume it naturally would take under the normal pressure of the air, and hence the values of heat of formation in column II are said to be measured under constant pressure. But as the symbols of the several hydrocarbons represent equal volumes (the same volume as that of a molecule of hydrogen gas represented by H_2) it is evident that the amount of condensation attending the formation of these compounds differs very greatly. Thus if we leave out of view the comparatively insignificant volume of the solid charcoal, it is evident that, while in the formation of CH_4 two volumes are condensed to one, in the formation of C_3H_8 four volumes are condensed to one, and it is evident that if we wish to study the chemical action solely we must eliminate the effect of this mechanical cause of the evolution of heat.

Now it can be calculated from well-known data, that at a mean temperature of 20° C. 580^c are set free for every molecular volume lost by condensation. In the formation of CH_4 from $2H_2$ one molecular volume is lost, and hence by subtracting 580^c from 20,150^c we obtain the amount of heat which would have been evolved had the product occupied the same volume as the factors from which it was formed. In like manner the

other values of column III have been calculated, and we thus obtain what may be called the heat of combination under constant volume.

TABLE I.

	I.	II.	III.
1. CH_4	213,530c	20,150c	19,570c
2. C_2H_6	373,330c	25,670c	24,510c
3. C_3H_8	533,500c	30,820c	29,950c
4. C_2H_4	334,800c	−4,160c	−4,740c
5. C_3H_6	495,200c	+760c	−400c
6. C_2H_2	310,570c	−48,290c	−48,290c

It may be noticed incidentally in connection with this table that the results confirm the previous conclusion of Favre and Silbermann, that the common difference of CH_2 between the members of a series of homologues corresponds in all cases to equal differences in the calorific power of their molecules. Thus from the above table we have

$$\begin{aligned} C_3H_6 - C_2H_6 &= 160{,}170^c \\ C_2H_6 - CH_4 &= 159{,}800^c \\ C_3H_6 - C_2H_4 &= 160{,}400^c \end{aligned}$$

and it is evident that the difference in question must be very closely 160,000c.

If, next, we compare the heat of formation under constant volume of all the hydrocarbon molecules which contain two atoms of carbon, we find between these values, also, a manifest relationship, and from this the remarkable conclusions of the paper we are noticing have been deduced.

TABLE II.

	Differences.
$C_2 = -a$,	$= 4r$
$C_2 + H_2 = -48{,}290^c$	$43{,}550 = 3r$
$C_2 + H_4 = -4{,}740^c$	$29{,}250 = 2r$
$C_2 + H_6 = +24{,}510^c$	$14{,}630 = r$
$2(C+H_4) = C_2 + H_8 = +39{,}140^c$	

Now just as $2CH_4$ is the limit of this series of molecules at one end, C_2 is evidently the limit of the series at the other end, and the symbol C_2 represents the theoretical molecule of carbon in the aeriform state occupying the unit of molecular volume, the two atoms of this molecule united by four bonds. Now if we represent the heat of formation of this molecule by $-a$, it will be seen that the relationship exhibited by the table gives us at once the means of calculating its value. But it is obvious that while the results given in the table are sufficiently accordant to exhibit their relationship, we should obtain quite different values for $-a$ by combining different results, and the only correct method is to bring all the determinations into the

calculation, combining the several values according to the principle of least squares. This Thomsen has done, and deduced for the most probable values

$$a = 106{,}630^c. \qquad r = 14{,}573.$$

With these values it is now easy to calculate the following table:

TABLE III.

Symbol.	Heat of Formation.		Differences.
C≡C	$-a$	$= -106{,}630^c$	$4r = 58{,}292$
HC≡CH	$-a + 4r$	$= -48{,}338^c$	$7r = 102{,}011$
$H_2C{=}CH_2$	$-a + 7r$	$= -4{,}619^c$	$9r = 131{,}157$
$H_3C{-}CH_3$	$-a + 9r$	$= 24{,}527^c$	$10r = 145{,}730$
$H_4C \mid CH_4$	$-a + 10r$	$= 39{,}100^c$	

and by comparing these calculated values with the observed values of table II it will be seen how closely they satisfy the observations. In table III the value $-a$ is the heat of formation of the assumed product C≡C from amorphous charcoal, and is the sum of two quantities, first the amount of heat absorbed in completely disassociating the atoms from the amorphous solid coal, and secondly the amount of heat that must be set free in the union of free carbon atoms in pairs by four bonds. If now we represent the first value by $-2d$ and the second as already proposed by v_4 we can evidently make the equation

$$-a = -2d + v_4 = -106{,}630^c. \qquad (1)$$

If a hydrocarbon is formed from amorphous carbon and hydrogen gas, the process must involve in addition to the disassociation of the atoms of the coal a division of the molecules of hydrogen gas also, and then a union of the hydrogen atoms to the carbon atoms, and perhaps also a union of the carbon atoms by the bonds which remain open one, two or three, as the case may be. Let us represent now by $-hh$ the heat absorbed in the disassociation of the atoms of hydrogen gas, and by ch the heat evolved from the union of the carbon and hydrogen atoms, and by v_3 v_2 v_1 the thermal effect resulting from the union of the carbon atoms by three bonds, two bonds, or a single bond, respectively, and we can at once deduce the following equation which shows the elements of which the heat of formation of acetylene consists:

$$HC{\equiv}CH = (C_2, H_2) = -2d + v_3 + 2ch - hh. \qquad (2)$$

It will be noticed that the symbols in lower case type are used to represent what we have called the thermal potentials of the atoms.

Assuming, as the facts of organic chemistry undoubtedly justify, that the thermal effect in the union of hydrogen and carbon atoms is always the same, and putting

$$2ch - hh = 2q^* \qquad (3)$$

we can readily deduce for the several hydrocarbons we are studying the following equations:

TABLE IV.

For	$C \equiv C$	$-a = -2d + v_4.$
	$HC \equiv CH$	$-a + 4r = -2d + v_3 + 2q$
	$H_2C = CH_2$	$-a + 7r = -2d + v_2 + 4q$
	$H_3C - CH_3$	$-a + 9r = -2d + v_1 + 6q$
	$H_4C \mid CH_4$	$-a + 10r = -2d \ldots + 8q$

and from the differences between the successive equations of this group we obtain the following simple relations between the quantities we are investigating:

$$\begin{aligned} v_4 - v_3 &= 2q - 4r \\ v_3 - v_2 &= 2q - 3r \\ v_2 - v_1 &= 2q - 2r \\ v_1 &= 2q - r \end{aligned}$$

It will be seen that we have thus made a very near approach to the determination of the thermal value of the several bonds between the carbon atoms, but as in the last group the number of unknown quantities exceeds by one the number of separate equations (it must be remembered that r is known), we must look for some other relation to furnish an additional condition. We can find this, in part at least, in the thermal relations of the oxides of carbon.

The heat of formation of the oxides of carbon from amorphous carbon and oxygen gas, and also the heat of formation of carbonic dioxide from carbonic oxide and oxygen gas are given in the following table:

TABLE V.

	Heat of Formation	
	Under constant pressure.	Under constant volume.
(C, O_2)	96,960c	96,960c
(CO, O)	68,370c	68,080c
(C, O)	28,590c	28,880c

The first of these values is the same as that used above, determined by Favre and Silbermann. The second has recently been re-determined by Thomsen. The third is not an experimental value, but deduced by simply subtracting the second from the first. As there is no condensation of gas volume when oxygen gas passes into carbonic dioxide, the heat of formation of carbonic dioxide under constant volume is the same as that under constant pressure. But when carbonic oxide gas unites with oxygen gas to form carbonic dioxide there is a condensation of one half a molecular volume, and hence in this case the value under constant volume is less than that under

* Notice that the quantity q is the result of two processes necessarily simultaneous, the breaking up of the hydrogen molecule and the union of the hydrogen and carbon atoms.

constant pressure by half 580^c (page 89). If now we analyze, after the principles applied to the hydrocarbons, the production of the oxides of carbon from amorphous carbon and oxygen gas we can readily deduce the following equations, the meaning of whose terms must be now evident:

$$2(C, O) = -2d - oo + 2co \quad (4)$$

$$(C, O_2) = -d - oo + oco \quad (5)$$

$$(C, O_2) - 2(C, O) = d - 2co + oco = 39{,}200^c. \text{ (Table V).} \quad (6)$$

Here $-oo$ represents the heat absorbed in dividing the molecules of oxygen gas, co the heat evolved in the union of atoms of carbon each with one atom of oxygen and oco the heat evolved in the union of atoms of carbon each with two atoms of oxygen. Could we assume that in the molecule of carbonic dioxide O=C=O the bonds were all of equal value we should necessarily have $oco = 2co$, and then from the last equation we should at once deduce

$$d = 39{,}200^c \quad (7)$$

and this being known the values of v_1 v_2 v_3 and v_4 could at once be definitely calculated from the previous equations. But although the assumption we have made is highly probable, it cannot as yet be proved, and it is possible that

$$2co - oco = x \text{ (some unknown quantity),}$$

and in this case we should have

$$d = 39{,}200^c + x,$$

a value which is independent of all hypothesis.

Returning now to the equations of table IV and taking the numerical values of the left-hand member in each of these equations from table III, we can at once find by simple substitution the following values:

$$q = 14{,}867^c + \frac{x}{4} \quad (8)$$

$$v_4 = C{\equiv}C = -28{,}230^c + 2x \quad (9)$$

$$v_3 = C{\equiv}C = +\ 688^c + \tfrac{3}{2}x \quad (10)$$

$$v_2 = C{=}C = +\ 15{,}033^c + x \quad (11)$$

$$v_1 = C{-}C = +\ 14{,}805^c + \tfrac{1}{2}x \quad (12)$$

Then by subtracting we find the thermal values of the several bonds, which take the following simple forms:

For the first bond $+\ 14{,}805^c + \frac{1}{2}x$ (13)

For the second bond $+\ 228^c + \frac{1}{2}x$ (14)

For the third bond $-\ 14{,}345^c + \frac{1}{2}x$ (15)

For the fourth bond $-\ 28{,}918^c + \frac{1}{2}x$ (16)

Of course if the probable supposition made above—in regard to the constitution of the molecules of CO_2—is correct, then the terms containing x disappear from all these values.

Again, a very remarkable relation appears when we compare together, as in table VI, the values of r, q, v_1 and v_2.

TABLE VI.

$$r = 14{,}573^c$$
$$q = 14{,}687^c + \frac{x}{4} = r + \frac{x}{4}$$
$$v_1 = 14{,}805^c + \frac{x}{2} = r + \frac{x}{2}$$
$$v_2 = 15{,}033^c + x = r + x.$$

It seems highly probable that the numerical term is the same in all these values; and the fact that the same constant frequently appears as a factor in the data of thermo-chemistry renders this conclusion still more probable. Thus we find that the heat of formation of HCl, NO and H_2O (in the condition steam) all as aeriform products under constant pressure is as follows:

$$H_2 + Cl_2 = 44{,}000^c = 3 \times 14{,}667^c$$
$$N_2 + O_2 = -43{,}150^c = 3 \times 14{,}383^c$$
$$H_2 + O = 57{,}610^c = 4 \times 14{,}402^c$$

The constant we have represented by r has evidently then an important significance, and its most probable value is that deduced by the method of least squares from all the observations on the series of hydrocarbons containing two atoms of carbon, as shown by table III. If we take then $r=14{,}573$ as the true value and $q=r+\frac{x}{4}$, we can easily deduce a second value of d from the data given in the table on page 92. Since $39{,}100^c=-2d+8q$, we have by substituting the value of q, $d=38{,}742^c+x$. From the oxides of carbon we have $d=39{,}200^c+x$. The mean of these values, omitting the last two figures as insignificant, is $d=38{,}900^c+x$.

The following are, now, the most probable values of the chief constants used in this investigation:

TABLE VII.

$$d = 38{,}900^c + x \qquad r = 14{,}570^c$$
$$q = r + \tfrac{1}{4}x \qquad co = 67{,}880^c$$
$$v_1 = r + \tfrac{1}{2}x \qquad v_3 = r + x$$
$$v_2 = + \tfrac{3}{2}x \qquad v_4 = -2r + 2x$$

With these values we can calculate the heat of formation, under constant volume, of a hydrocarbon from amorphous carbon and hydrogen gas, by means of the equation

$$(C_n, H_{2n}) = -nd + 2mq + \Sigma v \qquad (17)$$

in which the Σv is the sum of the calorific effects resulting from the union of the carbon atoms with each other. The results are independent of the unknown quantity x which is eliminated in reducing the equation. Since, as just stated the, unknown quantity x is always eliminated on solving the last

equation we can put $r=q=v_1=v_2=14{,}570$ and $v_3=0$. If also we put $\Sigma v=x_1 v_1+x_2 v_2+x_3 v_3$, ($x_1$, x_2, x_3 representing respectively the number of single, double and treble carbon bonds which occur in the molecule of the hydrocarbon in question), we can write equation (17) in the following more convenient form:

$$(C_n, H_{2m})=-n\times 38{,}900^c+(2m+x_1+x_3)\ 14{,}570^c \qquad (18)$$

This formula may be readily adapted to the various types of hydrocarbons (the paraffines, the olefines, the acetylenes, benzol, etc.), and by its aid we can calculate the heat of formation of different isomers according to their assumed structure, and then on comparing the calculated values with the direct results of experiment we may hope to obtain a new test of our theories of molecular structure.

In the series of paraffines the carbon atoms are all linked by single bonds, and no isomerism resulting from different relations of the carbon bonds is possible. Of course isomerism can result from differences in the grouping of the carbon atoms, but of this our thermo-chemical theory takes, as yet, no account. The general formula of a paraffine is $C_n H_{2n+2}$ and the number of single carbon bonds is $n-1$. We have then $2m=2n+2$; $x_1=n-1$; $x_2=0$. Making these substitutions in (18) we have

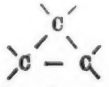
$$(C_n, H_{2n+2})=n\times 4810^c+14570^c \qquad (19)$$

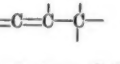
and the calculated values of the heat of formation under constant volume for the first three members of the series is as follows. The observed values in the parallel column shows as close accordance as could be expected.

TABLE VIII.

	Calculated.	Observed.
CH_4	19,380^c	19,570^c
C_2H_6	24,190^c	24,510^c
C_3H_8	29,000^c	39,950^c

In the olefines, however, isomerism resulting from different relations of the carbon bonds is possible; thus in the case of C_3H_6 we may have



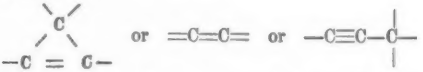
or


The general formula of an olefine being C_nH_{2n}, we have in the first case n single carbon bonds, and in the second case $n-2$ single bonds together with one double bond. Making the obvious substitutions in equation (18), we have for the heat of formation under constant volume

(1) $(C_n, H_{2n}) = n \times 4810^c$
(2) $(C_n, H_{2n}) = n \times 4810^c - 14{,}570^c$

For propylene $n = 3$, and the calculated values are $+14{,}430^c$ or -150^c. According to Thomsen's experiments the heat of formation of propylene prepared from isopropyliodide is -400^c, which would indicate that the generally received opinion in regard to the structure of this molecule is correct.

With the acetylenes we may have three distinct types of structure depending on the distribution of the carbon bonds. Thus for C_3H_4 either



The general symbol for an acetylene being $C_n\ H_{2n-2}$, we have in isomers of the first type $n-1$ single with one double bond; in isomers of second type $n-3$ single with two double bonds, and in isomers of the third type $n-2$ single with one treble bond. Making the substitutions as before, we obtain the following equations:

(1) $(C_n, H_{2n} - 2) = n \,.\, 4810^c - 29140^c$
(2) $(C_n, H_{2n} - 2) = n \,.\, 4810^c - 43710^c$
(3) $(C_n, H_{2n} - 2) = n \,.\, 4810^c - 58280^c$

and for allylene the three values are

-14710^c $\quad -29283^c$ $\quad -43856^c$

A determination of the heat of combustion of allylene was made by Berthelot, and since the heat of formation under constant volume deduced from his experiment is $-38{,}320^c$, it is probable that the last of the three symbols above represents the ordinary type of structure and this again is in accordance with the generally received opinion. The discrepancy between theory and observation, however, is quite large, and Thomsen intends to make further experiments on this substance.

One feature of this investigation of Thomsen, which might be overlooked unless attention was called to it, may be appropriately noticed in this connection. Omitting the unknown quantity x, which indeed is probably zero, we have for the values of the carbon bonds,

$$v_1 = r \qquad v_2 = r \qquad v_3 = 0 \qquad v_4 = -2r$$

and $r = 14\,570^c$. Hence it follows that the same energy results whether two carbon atoms unite by one or by two bonds, and that when they unite by three bonds no energy whatever is set free. At first sight this result seems strange, for we should naturally expect that the larger the number of bonds of union, the greater would be the force required to separate these atoms and hence the greater the manifestation of energy when these atoms united. On the contrary this investigation shows that if two carbon atoms are united by two bonds it requires no

energy to break one of the bonds if the other is left unimpaired, although it requires an energy measured by 14,770^{c} to break the last. While if the atoms are united by three bonds there is as strong a tendency to break away at the first bond as there is to hold together at the last bond.

Strange, however, as these results may appear, they harmonize with the known chemical relations of the paraffines, olefines and acetylenes. The stability of a chemical compound is to a certain extent proportional to the amount of energy set free in its production; since in order to decompose it the same amount of energy must be expended. In the paraffines, where all the carbon atoms are united by single bonds, and all the other bonds closed by hydrogen atoms, the molecules can not be decomposed unless one at least of the bonds is broken, and each break, whether between *cc* or *hc*, implies an expenditure of energy represented by 14,570^{c}. Here then is the explanation of the great stability of this class of hydrocarbons.

Passing next to the olefines we find a very different condition. In every molecule of these bodies two of the carbon atoms are united by a double bond, and one of the two can be broken without the expenditure of energy, so that atoms of chlorine or bromine have no work to do in order to unite at these points except to free themselves from their previous association. Hence arises the most familiar and characteristic chemical property of these substances.

Lastly, in the acetylenes the same tendency is still more strongly marked; for in the molecules of these bodies two of the carbon atoms are united by a treble bond, and the parting of either one or of two of these bonds is attended with a development of energy which is added to that resulting from the normal attraction of the carbon atoms for other radicals.

But the molecular structure of none of the more complex hydrocarbons has been so fully studied as that of benzol (C_6H_6), and we therefore have naturally waited with great interest for the results of the application of the new method of investigation to this compound. In the last number of the Berichte der deutsch. chem. Gesellschaft (Oct. 25, 1880), the expected results are published. In the benzol molecule, six only of the twenty-four bonds, which belong to six carbon atoms, are closed by hydrogen atoms leaving eighteen bonds to unite with each other, or nine connecting bonds as they are usually represented. Now we can conceive of a number of different ways in which these bonds may be distributed; but there are only two schemes which will satisfy the well-known facts in regard to the three types of isomeric derivatives of benzol. These schemes are that of Kékulé represented in fig. 1, and that of Ladenburg in fig. 2.

1.

2.

In the first scheme there are three single and three double bonds; in the second scheme nine single bonds. Making now the obvious substitutions in equation (18), we obtain for the heat of formation under constant volumes either

$$-60{,}360^c \text{ or } -16{,}650^c,$$

and for the heat of formation under constant pressure

$$-59{,}200^c \text{ or } -15{,}490^c.$$

We can now easily calculate, by the method already described, the heat of combustion of benzol vapor and we shall obtain

$$846{,}040^c \text{ or } 802{,}330^c.$$

Finally, Thomsen has re-determined with great care the same value and finds as the mean of five experiments that the heat of combustion of the molecular weight of benzol (72 gr.) is $805{,}800^c$. Hence he concludes:

"The six carbon atoms of benzol are united to each other by nine single bonds, and the previous assumption of a structure of benzol with three single and three double bonds is not supported by experiment."

Thomsen endeavors to prepare the way for the reception of this conclusion by emphasizing the statement that: "*The great resisting power of benzol militates against the presence of multiple bonds.*" But although it is true that chlorine or bromine act on benzol far more feebly than on ethylene or acetylene, nevertheless, under no great stress, benzol does yield addition products, and there can be no question that the original scheme of Kékulé harmonizes more chemical facts than the modification of this scheme proposed by Ladenburg. The new evidence is very important, but until its bearing has been more fully investigated it can not be regarded as conclusive. Indeed the interest of this investigation depends not so much on its results as on its method. It is a bold push beyond the beaten tracks of science, and although the first results of the venture must be accepted with caution, the skill displayed calls forth our admiration and the importance of the methods employed justifies this extended notice.

ART. IX.—*On a Determination of the Force of Gravity at the Summit of Fujiyama, Japan;* by T. C. MENDENHALL.

AN excursion to the summit of Fujiyama was made during the first ten days in August of the present year (1880), for the purpose of making a determination of the force of gravity at that point. In addition to four special students in physics from the Imperial University, the writer was accompanied by W. S. Chaplin, Esq., Professor of Civil Engineering, who determined the rate of the chronometer, and rendered much other valuable assistance. The preliminary experiments at the University in Tokio, as well as those upon the mountain, were mainly carried out, under the direction of the writer, by Messrs. Tanakadate and Tanaka, who had already gained much valuable experience in the determination of the force of gravity at Tokio.*

As stated in the previous paper, it was decided to make use of some form of the so-called "invariable" pendulum, and to compare a series of vibrations made at Tokio and at the top of the mountain. Owing to the difficulty of getting anything in the way of knife-edges made with sufficient accuracy in this country, nothing better could be done than to make use of a Kater's pendulum by Negretti and Zambra, after removing one of the knife-edges, the "tail-pieces" and all of the unnecessary parts. In the condition in which it was used, it consisted of a flat bar of brass 134 cm. long, 38 mm. wide and 4 mm. thick, with a knife-edge at a distance of about 15 cm. from one extremity. At nearly the lowest point was fixed the flat cylindrical weight, 10 cm. in diameter and 19 mm. thick, which was also of brass. On the short piece projecting above the knife-edge was an adjusting slide-piece which, as well as the cylindrical weight, was fixed in such a way that accidental movement was rendered impossible. In order to prevent any possibility of entire loss of results by means of the accidental injury of this pendulum, while being carried to and from the mountain, another of nearly the same vibrating period was prepared, the flat bar in this case being of well-seasoned wood, and the cylindrical weight being of somewhat different form. The knife-edge used was that which had been removed from the Kater's pendulum. During the month of July, both pendulums were vibrated in the Physical Laboratory of the University at Tokio in the same room and from the same pier referred to in the previous paper. Besides these two pendulums, the appliances consisted, in the main, of a Negus break-circuit chronometer, a chronograph and a portable transit instrument

* This Journal for August, 1880.

for rating the chronometer. Fortunately, all of the apparatus reached the top of the mountain in safety. The weather was exceptionally favorable during our stay, the nights being clear and the wind much less violent than is usual. The party occupied a small tent upon the summit of the mountain within a few feet of the edge of the crater, but it was evident that it could not be made a suitable place for carrying on the experiments. Fujiyama is a "holy mountain," and its ascent is accomplished yearly by thousands of pilgrims from all parts of Japan. This has resulted in the erection upon the summit of several small stone huts, which are used as temples. They are built of large and regularly-shaped pieces of lava, piled together so that the shrines within are perfectly protected from wind and weather. The priest in charge of one of these kindly permitted us to take possession of it during the few days of our stay, and it proved to be well adapted to our needs. In twenty-four hours after our arrival the pendulums were ready for work, and vibrations were continued during the greater portion of two days. Both pendulums were swung and the mode of recording the time was similar to that used in the previous determination at Tokio. The length of time in each series was, in general, thirty minutes. Temperature and barometric observations were made during the time of the experiments. Immediately after the pendulums were returned to Tokio they were again vibrated at the University, in order to discover if any change had taken place during their absence. With the results to be considered the brass pendulum alone is concerned. The two pendulums agree well with each other, but it is impossible to introduce any correction for the influence of moisture upon the wooden pendulum. Experiments made with it since the return from Fujiyama, under different degrees of humidity, show that such a correction would be necessary, so that it has not been introduced into the calculations, although it has served a useful purpose as a check. Many groups of vibrations were recorded both upon the mountain and at Tokio before and after the mountain work. Without quoting the individual results, it will be sufficient to remark that they agree among themselves slightly better than those given in the previous paper on the Tokio determination.

The vibrations at Tokio were all made under nearly the same conditions, and for convenience they were reduced to the common temperature of 23°·5 and barometer 30 inches. The time of vibration of the pendulum at Tokio, under these conditions, the mean of all the results, was:

$$t_1 = \cdot 999834 \text{ seconds.}$$

On the summit of the mountain the barometric pressure was tolerably constant at 19·5 inches and the temperature 8°·5, and

to these conditions they were all reduced after being corrected for arc, chronometer rate, &c. Finally the mean of all is reduced to the Tokio conditions as to temperature and pressure. The coefficient of expansion of the bar has not been determined, but it has been assumed to be ·00000187 for 1° C. This is a commonly accepted coefficient for brass, and a comparison of the vibration periods of the pendulum, under different temperatures, indicates that it cannot be far from correct. The correction for difference of barometric height is the most difficult to determine. Were it possible to vibrate the pendulum at the same place under pressures widely differing, it might be determined experimentally. Lacking this, I was, fortunately, able to refer to a recent elaborate and exhaustive discussion of the whole subject, from an experimental as well as from a theoretical standpoint, by C. S. Peirce, Esq., of the U. S. Coast Survey.* In this valuable memoir Mr. Peirce gives a graphical representation of the periods of vibration of his pendulum, under various pressures, from 30 inches of mercury down to what is practically a vacuum. By interpolation the period for any pressure between these limits can be very closely ascertained, as also the correction in going from one pressure to another. There are important differences between the pendulum used by Mr. Peirce and that in use here, the principal one being the difference in shape of the cylindrical weights, and the fact that in our pendulum only one cylinder was carried. Nevertheless, a fair approximation to the correction may be taken from his curve showing the results with "heavy end down," and observing that the differences in the two pendulums are such as to make the correction for our pendulums considerably less than that of the Coast Survey. In this way, by considering these differences the correction used in the reduction was determined. After it had been established, I was fortunate in getting possession of the complete memoir of Mr. Bailey, published in 1832, in which his elaborate experiments to determine this correction are given in full. Among the many pendulums which he used was one "No. 22," which, in form and dimensions, resembles ours quite closely, and the results of his experiments with it confirm the accuracy of the assumption made. It will be remembered that, as all results are reduced to the Tokio conditions, the correction is to be made for only about one-third of an atmosphere, so that, although important, it is less so than if the reduction had been to a vacuum. It is thought, therefore, that the correction applied is not far wrong. The corrected time, then, appears to be as follows:

* Measurements of Gravity at Initial Stations in America and Europe. Appendix No. 15, U. S. Coast Survey. Report for 1876.

Time on Summit—temperature, 8°·5; barometer, 19·5 inches;

$t_2 = 1{\cdot}000146$

Correction for temperature to reduce to 23°·5 . . .	·000140
Air correction	·000050

Time reduced to Tokio conditions.

$t_2 = 1{\cdot}000336$

Assuming the value of the force of gravity at Tokio to be as previously determined,

$$g_1 = 9{\cdot}7984$$

it follows that on the summit of Fujiyama,

$$g_2 = 9{\cdot}7886$$

Mr. Peirce has introduced an important correction to the time of vibration of a pendulum which depends upon the flexure of the support. I have carefully examined the support used in these experiments, attached to the massive stone pier, as described in a previous paper, and I can find no perceptible flexure. No means of making a minute examination were at hand on the summit of the mountain, but from the nature of the mounting there I am convinced that no considerable amount of flexure was possible.

The question at once suggests itself, whether it is possible to make use of this result in a determination of the density of the earth. While many of the circumstances are extremely favorable to this end, many of the data are, unfortunately, quite uncertain. It was originally planned to undertake at the same time a complete trigonometrical survey of the mountain, in order to obtain the necessary data as accurately as possible. This, however, we were obliged to defer, but it is hoped that it may be made at some future time. The following is offered as, perhaps, the nearest solution of the problem possible under the circumstances.

Fujiyama is an extinct volcano, whose height is known to be 2·35 miles very closely. It is renowned for its almost perfect symmetry of form, and for the fact that it rises solitary and alone out of a plain of considerable extent. Thus there is not much to consider except the attraction of the mountain itself. To determine this is, of course, a matter of considerable difficulty, but it is believed that a result not far out of the way is reached by making the following assumptions. Without any great error the mountain may be assumed to be a cone. The summit angle of this cone has been obtained by making careful measurements upon a large number of photographs of the mountain, taken from many different points of view. The mean of many measurements, which do not differ greatly among themselves, gives for this angle 138°. Another point of vital importance is the mean density of the mountain. The rock, as far as can

be discovered, is quite uniform in its composition throughout. It is a part of Japanese tradition, for it can hardly be called history, that the mountain was produced in a single night in the year B. C. 286. Many geologists are of opinion that it is mainly the result of a single eruption. A number of specimens from the surface have been examined, and it is found that when the air is retained in the pores the density is about 1·75, but when it is ground to a powder and the air excluded, it is 2·5. These facts were communicated to five geologists, at present employed in Japan, most of whom have considerable knowledge of the mountain from personal examination. They were requested to give an opinion as to what was the most probable mean density of the mountain. The mean of these results was 2·12, which is assumed to be correct in computing the result, and it also happens to be almost exactly the mean of the two densities given above. The time of vibration of the pendulum at the level of the sea at Tokio has been corrected for the difference of latitude between Tokio and Fujiyama, which is about 19′, by means of the well known formula. When this is done it becomes

$$t_s = 999847$$

From these times of vibration the part of the attraction on the summit, which is due to the mountain itself, is easily computed, and then the attraction of the mountain in terms of the density of the earth. The mountain is assumed to be a cone, whose semi-vertical angle is 69° and density 2·12, and its attraction on a particle at its vertex is computed. Equating these results the density of the earth results as follows:

$$D = 5·77$$

This result is somewhat greater than the generally accepted density, but when the uncertainty of some of the data is considered it must be regarded as remarkably lose.

It is believed that the density of the mountain is the most uncertain of all the factors, and it will be of interest to reverse the problem and, assuming the density of the earth to be 5·67, as determined by Baily, find, by combining this with the pendulum experiments, the density of the mountain. When this is done the result is:

$$d = 2·08$$

It seems to me that these experiments establish, with considerable certainty, the fact that the mountain is, for some reason, deficient in attraction, which leads to many questions of great interest concerning the possible or probable structure of the mountain. It is possible, therefore, that these results may be of some value to geologists who are interested in the structure of volcanoes.

ART. X.—*Extract from a Report to* C. P. PATTERSON, *Supt. Coast and Geodetic Survey;* by W. H. DALL, Assistant in charge of schooner "Yukon," employed on the coast of Alaska.

ON the 11th of August, after a stormy and tedious passage, we arrived at Plover Bay, in Eastern Siberia, near Bering Strait. The longitude of this place has been independently determined from San Francisco and St. Petersburg, so that it afforded a convenient place for rating our chronometers before beginning work on our coast in the Arctic. We obtained good observations for time and a full series of magnetics.

The surroundings of the anchorage are barren and dreary, the rocky hills covered with material comminuted by the frost and presenting little vegetation, except a luxuriant growth of lichens. The people here are the Asiatic Eskimo, described by Nordenskjold, modern emigrants from America, few in number and deteriorated by use of alcohol obtained from illicit traders. They gave us no trouble, however, and the fine weather made our stay here quite pleasant. When we arrived, late at night, two canoes, containing the entire population, came out to meet us, it being the practice of the traders to give everybody a drink on their arrival "to facilitate trade." They asked for "lum" (rum) and were informed we had none. "No go lum! American schooner no got lum! (with rising indignation), Lie! Lum got!" was the exclamation of a linguist among them. However, much to their disgust, they were finally convinced we were not traders and departed, leaving us in peace.

On the 14th of August we sailed from Plover Bay to the Arctic, having light breezes and fine weather. On the 20th, we anchored behind Cape Lisburne, on the American shore in the Arctic, nearly 200 miles north of Bering Strait. The air was balmy, the sun warm and bright: no snow or ice visible on land or water, and the banks covered with flowers, among which daisies, monkshood and forget-me-nots were conspicuous. The natives were the most curious and annoying beggars we met during the voyage, and it was necessary to have a guard on hand to keep an eye on the instrument cases, etc., while observations were going on, lest they should be stolen. However, we lost nothing except our patience now and then, and obtained good observations for latitude, time, and a good series of magnetics.

The land hereabouts is high for the most part, and contains beds of good coal, belonging to the true Carboniferous period, with limestones containing many fossil corals and other Paleozoic remains. The revenue cutter "Corwin" coaled several

times from these beds, which are near the beach, and reported the coal of good quality. It will prove of importance if steam whaleships come into general use in this region.

We sailed for Icy Cape the next day, but the wind being light, did not reach it until the 25th of August. That evening we proceeded, seeing several whaleships, and the following afternoon spoke the cutter, who reported ice near at hand, and that she did not think we could proceed much further with safety. We soon made the ice, which was about eleven miles off shore and nearly parallel with it, consisting of floating fragments, much soiled with mud and rising seldom more than ten feet above the water, forming a fringe around of solid fields of rather rough pack ice, extending beyond the range of vision from the masthead.

We spoke several of the whalers as we proceeded. All represented the ice as moving in toward the land. The night before it had moved in eighteen miles, there being a strong northerly wind. After passing Point Belcher and finding that off the Sea Horse Islands there was only a quarter of a mile of open water, we decided to anchor and await further developments. The weather was cloudy with heavy wet fog. That night the ice moved in three miles toward shore; the wind also strengthened; the weather showed no signs of improvement, and, rather than risk being grounded by the ice with only two months' provisions on board, I decided to take advantage of the favorable wind and return to the southward, where there was still much work to do. We reached nearly the latitude of Point Barrow, and were about fifty miles westward from it. The country in this vicinity was almost perfectly flat, and nothing like a hill or rise was visible anywhere.

The vegetation was quite dense on the land, but less profuse than at Cape Lisburne and with fewer flowers. Large lumps of coal lay on the beach, which had been pushed up by the ice from the bottom of the sea, but no bed rock could be seen, and the soil seemed to be chiefly a sort of red gravel. At a depth of two feet is a stratum of pure ice (not frozen soil) of unknown depth. This formation extends, with occasional gaps, north to Point Barrow and east to Return Reef, where the ice layer is about six feet above the level of the sea. It goes south at least as far as Icy Cape without any decided break, and is found in different localities as far south as Kotzebue Sound.

We sailed on the 28th of August from Point Belcher and entered Kotzebue Sound on the 30th. The next morning, August 31st, we anchored in Chamisso Harbor, Eschscholtz Bay, in which vicinity we remained four days. We were beset with natives from all quarters, eager to trade and much disap-

pointed that we had nothing to sell. It was fortunate that no rumsellers had been in the vicinity, for the number of the natives was so great that they might easily have taken charge if they had been so disposed.

We obtained a first rate series of observations of all kinds on Chamisso Island. On the 2d of September, the weather being unsuitable for observations, I took the large boat and crew and crossed the bay toward Elephant Point, the site of the extraordinary ice formation, first observed by Kotzebue and afterward reported on by Beechey and Seemann.

We landed on a small, low point near some old huts, and proceeded along the beach about a mile, the banks being chiefly composed of volcanic breccia or a slaty gneissoid rock. They rose fifteen to fifty feet in height above the sea, rising inland to hilly slopes, without peaks and probably not attaining more than three or four hundred feet anywhere in the vicinity.

As we passed eastward along the beach, a change took place in the character of the banks. They became lower and the rise inland was less. From reddish volcanic rock they changed to a grayish clay, containing much vegetable matter, which, in some places, was in strata in the clay, and in others indiscriminately mixed with it. Near the beginning of these clay banks, where they were quite low, not rising over twenty feet above the shore, we noticed one layer of sphagnum (bog moss) containing marl of fresh water shells, belonging to the genera *Pisidium*, *Valvata*, etc. This layer was about six inches thick. The clay was of a very tough consistency, and, though wet, did not stick to or yield much under the feet. The sea breaks against the foot of these banks and undermines them, causing them to fall down, and the rough irregular talus that results is mingled with turf and bushes from the surface above. A little farther on a perpendicular surface of ice was noticed in the face of the bank. It appeared to be solid and free from mixture of soil, except on the outside. The banks continued to increase slowly but regularly in height as we passed eastward. A little farther on another ice-face presented itself on a larger scale. This continues about two miles and a half to Elephant Point, where the high land turns abruptly to the south and west, and we followed it no farther. The point itself is boggy and low, and is continued from the foot of the high land, perhaps half a mile to the eastward, forming the northwest headland to a shallow bay of considerable extent.

To return to the "cliffs": these for a considerable distance were double; that is, there was an ice-face exposed near the beach with a small talus in front of it, and covered with a coating of soil two or three feet thick, on which luxuriant vegetation was growing. All this might be thirty feet in height.

On climbing to the brow of this bank, the rise from that brow proved to be broken, hummocky and full of crevices and holes; in fact, a second talus on a larger scale, ascending to the foot of a second ice-face, above which was a layer of soil one to three feet thick covered with herbage.

The brow of this second bluff we estimated at eighty feet or more above the sea. Thence the land rose slowly and gradually to a rounded ridge, reaching the height of three or four hundred feet only, at a distance of several miles from the sea, with its axis in a north-and-south direction, a low valley west from it, the shallow bay at Elephant Point east from it, and its northern end abutting in the cliffs above described on the southern shore of Eschscholtz Bay. There were no mountains or other high land about this ridge in any direction, all the surface around was lower than the ridge itself.

About half a mile from the sea, on the highest part of the ridge perhaps two hundred and fifty feet above high water mark, at a depth of a foot, we came to a solidly frozen stratum, consisting chiefly of bog moss and vegetable mould, but containing good-sized lumps of clear ice. There seemed no reason to doubt that an extension of the digging would have brought us to solid, clear ice, such as was visible at the face of the bluff below. That is to say, it appeared that the ridge itself, two miles wide and two hundred and fifty feet high, was chiefly composed of solid ice overlaid with clay and vegetable mould. It was noticeable that there was much less clay over the top of the upper ice-face than was visible over the lower one, or over the single face when there was but one and the land and bluff were low near the beach. There also seemed to be less vegetable matter. Near the beach six or eight feet of clay were observed in some places, without counting what might be considered as talus matter from further up the hillside. In one place only did we notice a little fine, reddish gravel, and nowhere in the talus or strata any stones.

The ice-face near the beach was not uniform. In many places it was covered with clay to the water's edge. In others, where the bank was less than ten feet high, the turf had bent without breaking after being undermined, and presented a mossy and herbaceous front, curving over quite to high water mark.

The ice in general had a semi-stratified appearance, as if it still retained the horizontal plane in which it originally congealed. The surface was always soiled by dirty water from the earth above. This dirt was, however, merely superficial. The outer inch or two of the ice seemed granular, like compacted hail, and was sometimes whitish. The inside was solid and transparent, or slightly yellow-tinged, like peat water,

but never greenish or bluish like glacier ice. But in many places the ice presented the aspect of immense cakes or fragments, irregularly disposed, over which it appeared as if the clay, etc., had been deposited. Small pinnacles of ice ran up into the clay in some places, and, above, holes were seen in the face of the clay-bank, where it looked as if a detached fragment of ice had been and had been melted out, leaving its mould in the clay quite perfect.

In other places the ice was penetrated with deep holes, into which the clay and vegetable matter had been deposited in layers, and which (the ice melting away from around them) appeared as clay and muck cylinders on the ice-face. Large rounded holes or excavations of irregular form had evidently existed on the top of the ice before the clay, etc., had been deposited. These were usually filled with a finer-grained deposit of clay with less vegetable matter, and the layers were waved, as if the deposit had been affected by current action while going on.

In these places was noticed, especially, the most unexpected fact connected with the whole formation, namely, a strong, peculiar smell, as of rotting animal matter, burnt leather and stable manure combined. This odor was not confined to the spots above mentioned, and was not quite the same at all places, but had the same general character wherever it was noticed. A large part of the clay had no particular smell. At the places where the odor was strongest, it was observed to emanate particularly from darker, pasty spots in the clay (though permateing elsewhere), leading to the supposition that these might be remains of the soft parts of the mammoth and other animals, whose bones are daily washed out by the sea from the clay talus.

At or near these spots, where the odor was strongest, a rusty, red lichen, or lichen-like fungus, grew on the wet clay of the talus in extensive patches. Some of these, of the bad smelling deposit, and as many bones of the mammoth, fossil buffalo, etc., as we could carry were secured. These included a mammoth tusk, with both ends gone, but still five and a half feet long and six inches in diameter, which I shall forward to the office. Dwarf birches, alders, seven or eight feet high, with stems three inches in diameter, and a luxuriant growth of herbage, including numerous very toothsome berries, grew with the roots less than a foot from perpetual solid ice.

The formation of the surrounding country shows no high land or rocky hills, from which a glacier might have been derived and then covered with debris from their sides. The continuity of the mossy surface showed that the ice must be quite destitute of motion, and the circumstances appeared to point to

one conclusion, that there is here a ridge of solid ice, rising several hundred feet above the sea, and higher than any of the land about it, and older than the mammoth and fossil horse: this ice taking upon itself the functions of a regular stratified rock. The formation, though visited before, has not hitherto been intelligibly described from a geological standpoint. Though many facts may remain to be investigated, and whatever be the conclusions as to its origin and mode of preservation, it certainly remains one of the most wonderful and puzzling geological phenomena in existence.

On the 3d of September we sailed from Chamisso Harbor for Bering Strait, arriving off East Cape of Asia about 6 A. M. of the 5th. Broken ice intervened between us and the shore, and the bight southward from the cape was packed full of ice. We could not approach nearer to the shore than four miles.

The wind was fresh but the opportunity seemed tolerably favorable, and I concluded to attempt making the hydrothermal section across Bering Strait at once, rather than risk the chance of a more favorable opportunity with its possible long delays. We therefore proceeded across the strait at its narrowest part, taking temperatures at short intervals on the surface and soundings with serial five-fathom temperatures every four miles, as nearly as we could determine at the time.

The shallow depth of water facilitated our work very much, as we were able to bring up several gallons of water in the bivalve water-buckets, from any depth, in a few seconds and test it with an unprotected thermometer, giving us much more accurate results than the Casella thermometers are capable of. We found the wind growing more and more severe, and were obliged to reef down during the latter part of the day, but succeeded in getting our last serial sounding, completing the section at a time when we should at any rate have had to cease work, so heavy was the sea produced by the wind against the tide. Finally, we were very glad to run for shelter to Port Clarence, which we reached the following morning quite early.

The diagrams* appended to this report will show the details of the work, and I may say here, that the general conclusion reached from these, with previous and subsequent observations in the strait, was as follows: The water is warmest toward the American side, and cools gradually toward the Asiatic side. The highest temperature is 48° F. and the lowest about 36° F. The uniform succession of the vertical curves, representing degrees of temperature, is somewhat interfered with by an eddy around the Diomede Islets in the middle of the strait, but is otherwise very regular.

* The diagram of hydrothermal section, showing surface temperatures and depth, is the only one that could be engraved in time for this issue.

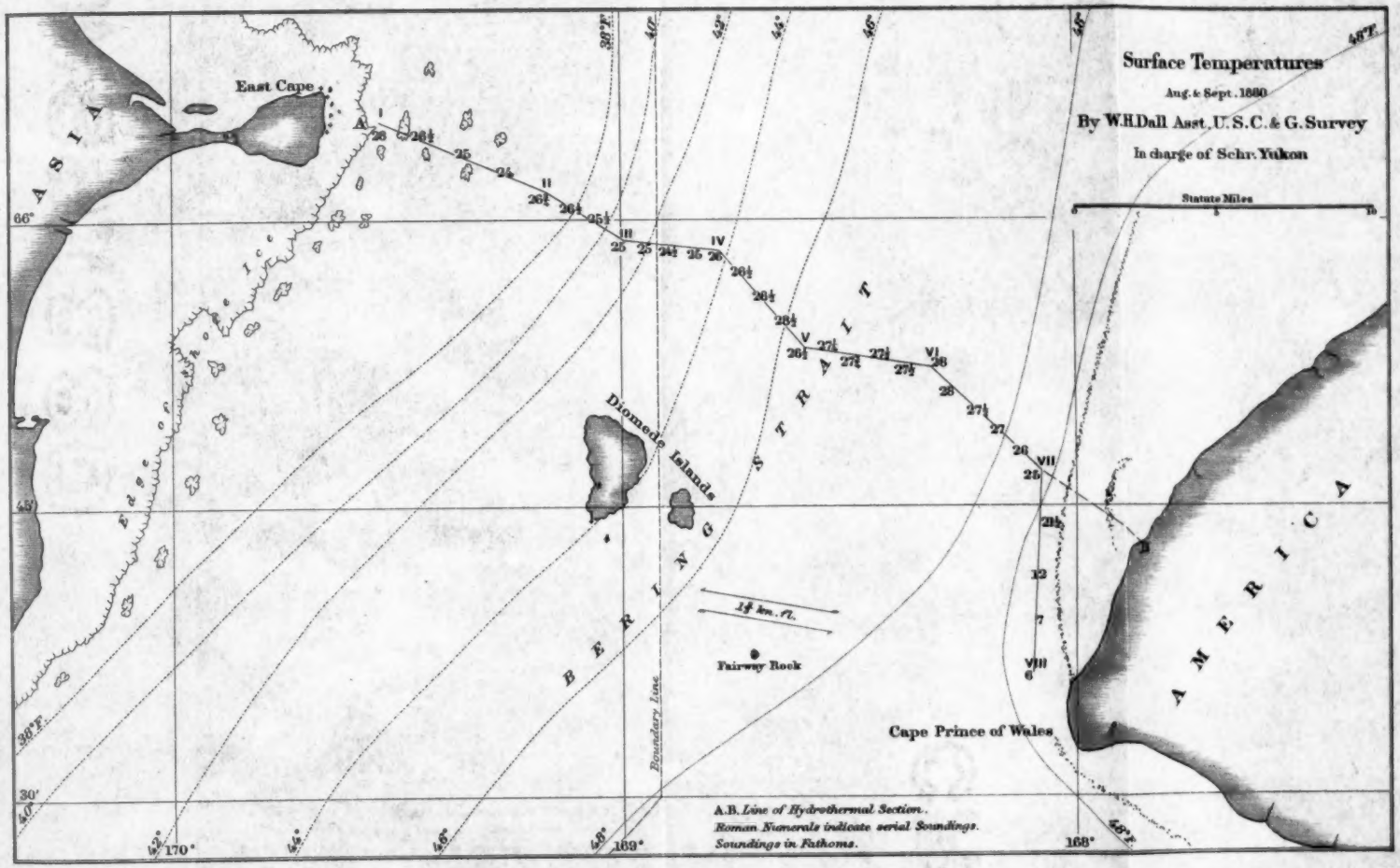
The uniformity of the temperatures from top to bottom, does away with the idea of a sub-surface current from the Arctic Ocean, carrying cold water southward, a result I had expected, and confirmatory of my suspicions expressed in the Appendix to the Coast Pilot of Alaska, and of Onatzevich's observations on the Kamchatka coast.

Our current observations showed another conclusion to be probable, though a more thorough investigation will be required to place it beyond question, namely, that the northerly current through the strait and along the Arctic Ocean is chiefly dependent on the tide for its force and direction, and on the warming of the shallow waters of Norton Sound and the "Yukon" and vicinity, for its high temperature, which is greater than any of the Bering Sea water south of St. Lawrence Island. This would agree with the observations of explorers along the Siberian coasts and elsewhere, where large bodies of comparatively warm water, derived from large rivers, are poured out over shallow areas of a cold sea basin.

The direction of the current in the strait, when we were lying near the Diomedes, was reversed by the tide, and the vessel tailed in opposite directions during flood and ebb. The rate varied with the strength of the tide, and during our stay did not exceed three knots. The directions agreed with the trend of the land on either side of Cape Prince of Wales (along which the tide runs and would naturally gather its greatest velocity), and as a consequence diagonally across the strait.

Early in the morning of the 10th of September we arrived at the Diomedes, and were most fortunate, notwithstanding a very strong breeze was blowing, to be able to make a lee under the end of the Big Diomede, and a landing on the snow in a small gully, where observations could be taken. Had the wind varied half a point from its direction this could not have been done, and weeks might have passed without an opportunity.

These islands are granite domes, rising abruptly from the water, and their sides rendered perpendicular by the action of the sea. The water is bold to; there are no beaches. The weather has acted on the surface of the top of the islands so as to make a sort of broken table-land, the drainage from which has cut a few gullies in the granite bluffs. By digging into the rubbish and massing it below, the natives have obtained spaces sufficiently level to hold a few huts. There are two villages, one on each island. Fairway Rock, at no great distance, is uninhabited and almost inaccessible. Near our station was one hut—empty—and by climbing up the gully, by steps laboriously excavated in the crumbling granite, the natives were able to go over the top of the island to the village on the other side.


Surface Temperatures
Aug. & Sept. 1880
By W.H.Dall Asst. U.S.C.& G.Survey
In charge of Schr. Yukon
Statute Miles
East Cape
ASIA
AMERICA
Diomede Islands
BERING STRAIT
Fairway Rock
Cape Prince of Wales
Boundary Line
A.B. Line of Hydrothermal Section.
Roman Numerals indicate serial Soundings.
Soundings in Fathoms.
66°
65°
30'
170°
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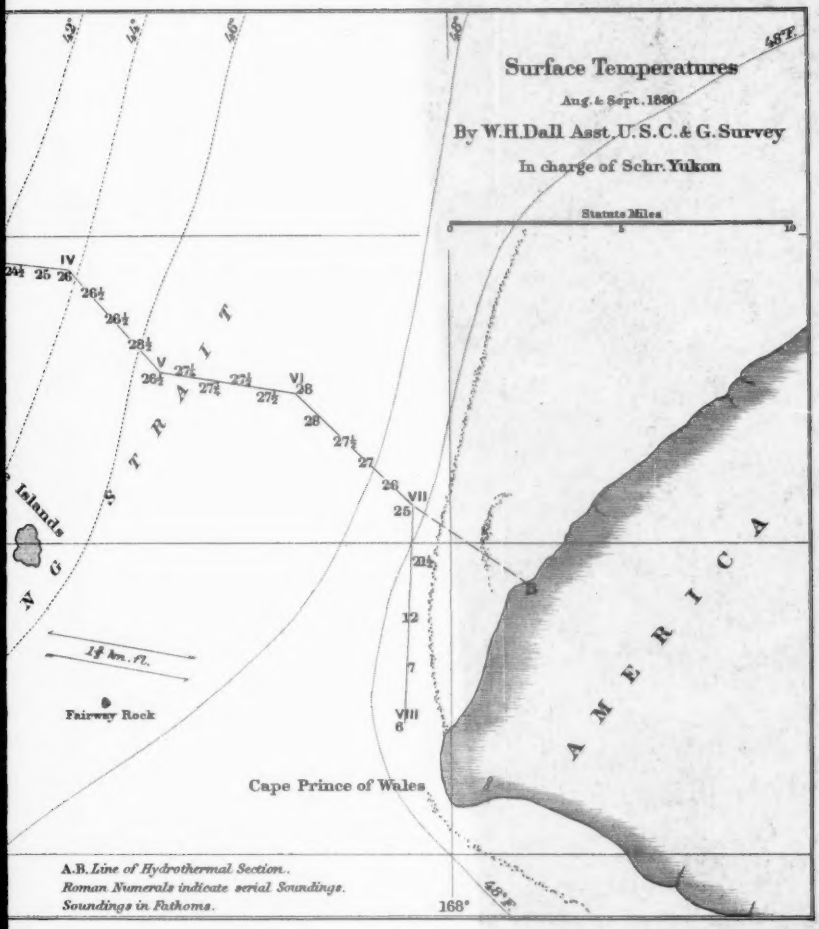
168°


Surface Temperatures
Aug. & Sept. 1880
By W.H.Dall Asst. U.S.C.& G.Survey
In charge of Schr. Yukon
Statute Miles
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5
10
48°F.
46°
44°
42°
40°
STRAIT
BERING
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Islands
Fairway Rock
Cape Prince of Wales
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VI
VII
VIII
24½
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7
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1¾ km. ft.
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A.B. Line of Hydrothermal Section..
Roman Numerals indicate serial Soundings.
Soundings in Fathoms.

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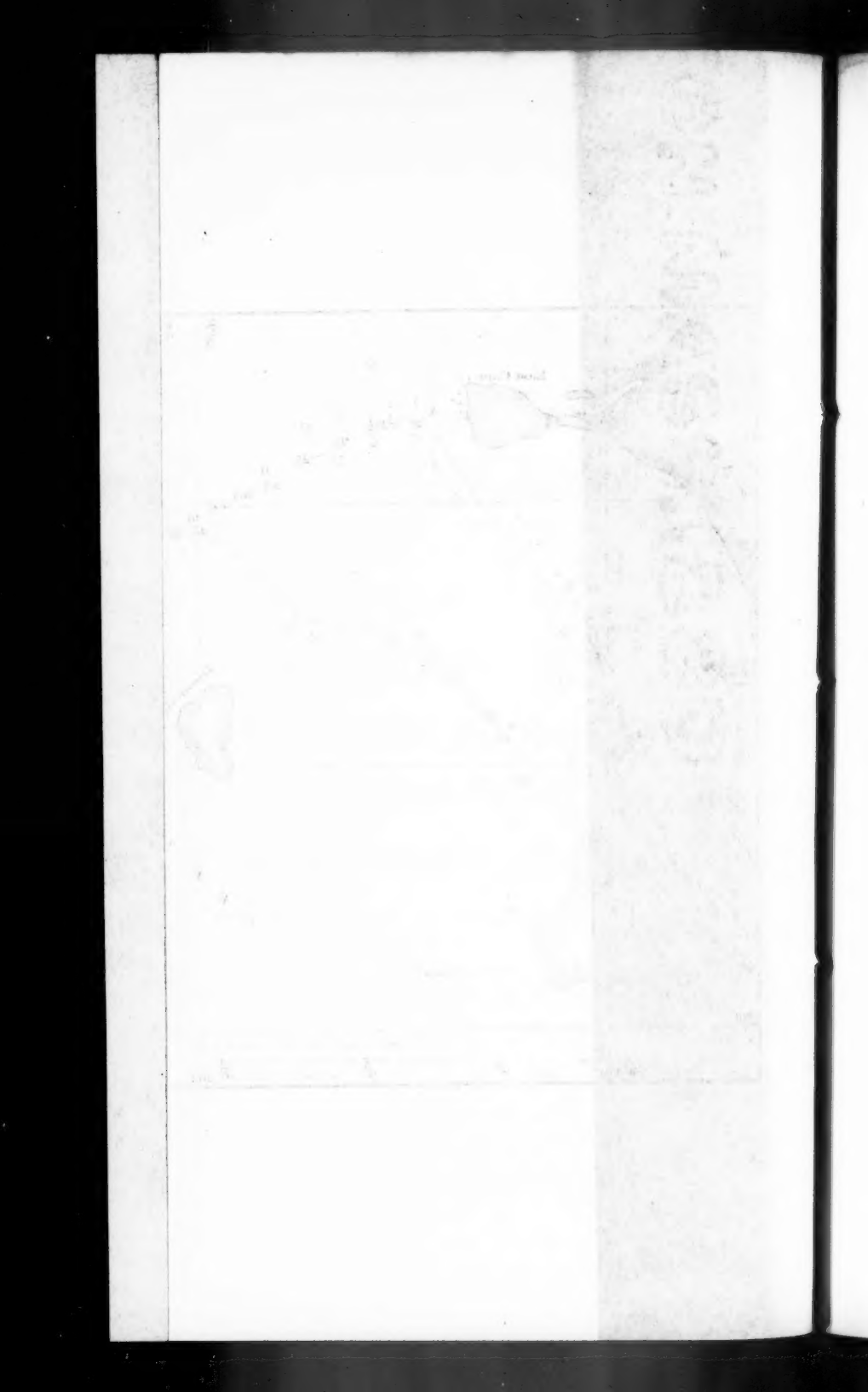


Millions of birds afford a large item of subsistence, and seal, and later in the season some walrus, are taken by these natives, who act as middle-men in trading between Asia and America. A short but satisfactory set, each, of time, latitude, dip, intensity and azimuth was obtained, with angles determining the position of the adjacent island and the prominent features of the mainland on either side.

One of the most important results of the occupation of this station was the determination of the fact that the boundary line, as defined by the treaty, does pass between the two islands without touching either, as was assumed in that document, but which had been put in doubt by certain erroneous charts of the vicinity.

I may say that the decreasing easterly variation which we pointed out in 1873, was extremely marked in the northern stations occupied, some of the results showing five or six degrees less variation than is indicated on the latest charts. A thorough explication of the results must, of course, await the final revision of the computations.

Art. XI.—*Relation of Devonian Insects to later and existing types;* by Samuel H. Scudder.*

It only remains to sum up the results of this reëxamination of the Devonian insects, and especially to discuss their relation to later or now existing types. This may best be done by a separate consideration of the following points:—

1. There is nothing in the structure of these earliest known insects to interfere with a former conclusion† that *the general type of wing structure has remained unaltered from the earliest times.* Three of these six insects (Gerephemera, Homothetus and Xenoneura) have been shown to possess a very peculiar neuration, dissimilar from both Carboniferous and modern types. As will also be shown under the tenth head, the dissimilarity of structure of all the Devonian insects is much greater than would be anticipated; yet all the features of neuration can be brought into perfect harmony with the system laid down by Heer.

2. *These earliest insects were hexapods*, and as far as the record goes preceded in time both arachnids and myriapods. This is shown only by the wings, which in all known insects belong only to hexapods, and in the nature of things prove the earlier

* This summary of results is the conclusion of a memoir by Mr. Scudder on the Devonian Insects of New Brunswick, published in the Anniversary Memoirs of the Boston Society of Natural History, 1880.

† The Early types of Insects. Mem. Bost. Soc. Nat. Hist., iii, 21.

apparition of that group. This, however, is so improbable on any hypothesis, that we must conclude the record to be defective.

3. *They were all lower Heterometabola.* As wings are the only parts preserved, we cannot tell from the remains themselves whether they belong to sucking or to biting insects; for, as was shown in the essay already referred to, this point must be considered undetermined concerning many of the older insects until more complete remains are discovered.

They are all allied or belong to the Neuroptera, using the word in its widest sense. At least two of the genera (Platephemera and Gerephemera) must be considered as having a closer relationship to Pseudoneuroptera than to Neuroptera proper, and as having indeed no special affinity to the true Neuroptera other than is found in Palæodictyoptera. Two others (Lithentomum and Xenoneura), on the contrary, are plainly more nearly related to the true Neuroptera than to the Pseudoneuroptera, and also show no special affinity to true Neuroptera other than is found in Palæodictyoptera. A fifth (Homothetus), which has comparatively little in common with the Palæodictyoptera, is perhaps more nearly related to the true Neuroptera than to the Pseudoneuroptera, although its pseudoneuropterous characters are of a striking nature. Of the sixth (Dyscritus) the remains are far too imperfect to judge clearly, but the choice lies rather with the Pseudoneuroptera or with Homothetus. The Devonian insects are then about equally divided in structural features between Neuroptera proper and Pseudoneuroptera, and none exhibit any special orthopterous, hemipterous or coleopterous characteristics.

4. *Nearly all are synthetic types of a comparatively narrow range.* This has been stated in substance in the preceding paragraph, but may receive additional illustration here. Thus Platephemera may be looked upon as an Ephemerid with an odonate reticulation; Homothetus might be designated as a Sialid with an odonate structure of the main branch of the scapular vein; and under each of the species will be found detailed accounts of any combination of the characters which it possesses.

5. *Nearly all bear marks of affinity to the Carboniferous Palæodictyoptera*, either in the reticulated surface of the wing, its longitudinal neuration, or both. But besides this there are some, such as Gerephemera and Xenoneura, in which the resemblance is marked. Most of the species, however, even including the two mentioned, show palæodictyopterous characters only on what might be called the neuropterous side; and their divergence from the Carboniferous Palæodictyoptera is so great that they can scarcely be placed directly with the mass

of Palæozoic insects, where we find a very common type of wing structure, into which the neuration of Devonian insects only partially fits. For:

6. *On the other hand, they are often of more and not less complicated structure than most Palæodictyoptera.* This is true of the three genera mentioned above with peculiar neuration, but not necessarily of the others, and it is especially true when they are compared with the genus Dictyoneura and its immediate allies. There are other Palæodictyoptera in the Carboniferous period with more complicated neuration than Dictyoneura, but these three Devonian insects apparently surpass them, as well as very nearly all other Carboniferous insects. Futhermore:

7. With the exception of the general statement under the fifth head, *they bear little special relation to Carboniferous forms, having a distinct facies of their own.* This is very striking; it would certainly not be possible to collect six wings in one locality in the Carboniferous rocks, which would not prove, by their affinity with those already known, the Carboniferous age of the deposit. Yet we find in this Devonian locality not a single one of Palæoblattariæ or anything resembling them; and more than half the known insects of the Carboniferous period belong to that type. The next most prevailing Carboniferous type is Dictyoneura and its near allies, with their reticulated wings. Gerephemera only, of all the Devonian insects, shows any real and close affinity with them; and even here the details of the wing structure, as shown above, are very different. The apical half of the wing of Xenoneura (as I have *supposed* it to be formed) also bears a striking resemblance to the dictyoneuran wing; but the base, which is preserved, and where the more important features lie, is totally different. The only other wing which shows particular resemblance to any Carboniferous form (we must omit Dyscritus from this consideration, as being too imperfect to be of any value) is Platephemera, where we find a certain general resemblance to *Ephemerites Rückerti* Gein., and *Acridites priscus* Andr., but this is simply in the form of the wing and the general course of the nervules; when we examine the details of the neuration more closely we find it altogether different, and the reticulation of the wing polygonal and not quadrate as in the Carboniferous types.* In this respect indeed, Platephemera differs not only from all modern Ephemeridæ, but also from those of other geological periods.† Another prevailing Carboniferous type,

* Dr. H. B. Geinitz has kindly reëxamined *Ephemerites Rückerti* at my request, and states that the reticulation is in general tetragonal, but that at the extreme outer margin the cells appear in a few places to be elliptical five- or six-sided.

† The Dictyoneuræ and their allies, as may be inferred, are considered as belonging to the Palæodictyoptera, although their ephemeridan affinities are not disregarded.

the Termitina, is altogether absent from the Devonian. Half a dozen wings, therefore, from rocks known to be either Devonian or Carboniferous, would probably establish their age.

8. *The Devonian insects were of great size, had membranous wings, and were probably aquatic in early life.* The last statement is simply inferred from the fact that all the modern types most nearly allied to them are now aquatic. As to the first, some statements have already been made; their expanse of wing probably varied from 40 to 175 mm. and averaged 107 mm. Xenoneura was much smaller than any of the others, its expanse not exceeding four centimeters, while the probable expanse of all the rest was generally more than a decimeter, only Homothetus falling below this figure. Indeed if Xenoneura be omitted, the average expanse of wing was 121 mm., an expanse which might well be compared to that of the Æschnidæ, the largest, as a group, of living Odonata. There is no trace of coriaceous structure in any of the wings, nor in any are there thickened and approximate nervules—one stage of the approach to a coriaceous texture.

9. *Some of the Devonian insects are plainly precursors of existing forms, while others seem to have left no trace.* The best examples of the former are Platephemera, an aberrant form of an existing family; and Homothetus, which, while totally different in the combination of its characters from anything known among living or fossil insects, is the only Paleozoic insect possessing that peculiar arrangement of veins found at the base of the wings of the Odonata, typified by the arculus, a structure previously known only as early as the Jurassic. Examples of the latter are Gerephemera, which has a multiplicity of simple parallel veins, next the costal margin of the wing, such as no other insect, ancient or modern, is known to possess; and Xenoneura, where the relationship of the internomedian branches to each other and to the rest of the wing is altogether abnormal. If too, the concentric ridges, formerly interpreted by me as possibly representing a stridulating organ, should eventually be proved an actual part of the wing, we should have here a structure which has never since been repeated even in any modified form.

10. *They show a remarkable variety of structure, indicating an abundance of insect life at that epoch.* This is the more noticeable from their belonging to a single type of forms, as stated under the seventh head, where we have seen that their neuration does not accord with the commoner type of wing structure found in Paleozoic insects.* These six wings exhibit a diversity of neuration quite as great as is found among the hundred or more species of the Carboniferous epoch; in some, such as

*Cf. Mem. Bost. Soc. Nat. Hist., iii, 19, note 1.

Platephemera, the structure is very simple; in others, like Homothetus and Xenoneura, it is somewhat complicated; some of the wings, as Platephemera and Gerephemera, are reticulated; the others possess only transverse cross veins more or less distinct and direct. No two wings can be referred to the same family, unless Dyscritus belongs with Homothetus—a point which cannot be determined from the great imperfection of the former. This compels us to admit the strong probability of an abundant insect fauna at that epoch. Although many Paleozoic localities can boast a greater diversity of insect types if we look upon their general structure as developed in after ages, not one in the world has produced wings exhibiting in themselves a wider diversity of neuration; for the neuration of the Palæodictyoptera is not more essentially distinct from that of the Palæoblattariæ or of the ancient Termitina, than that of Platephemera or Gerephemera on the one hand is from that of Homothetus or Xenoneura on the other. Unconsciously, perhaps, we allow our knowledge of existing types and their past history to modify our appreciation of distinctions between ancient forms. For while we can plainly see in the Palæoblattariæ the progenitors of living insects of one order, and in other ancient types the ancestors of living representatives of another order; were we unfamiliar with the divergence of these orders in modern times, we should not think of separating ordinarily their ancestors of the Carboniferous epoch. It may easily be seen, then, how it is possible to find in these Devonian insects—all Neuroptera or neuropterous Palæodictyoptera—a diversity of wing structure greater than is found in the Carboniferous representatives of the modern Neuroptera, Orthoptera and Hemiptera.

11. *The Devonian insects also differ remarkably from all other known types, ancient or modern; and some of them appear to be even more complicated than their nearest living allies.* With the exception of Platephemera, not one of them can be referred to any family of insects previously known, living or fossil; and even Platephemera, as shown above, differs strikingly from all other members of the family in which it is placed, both in general neuration and in reticulation; to a greater degree even than the most abberrant genera of that family do from the normal type. This same genus is also more complicated in wing structure than its modern allies; the reticulation of the wing in certain structurally defined areas is polygonal and tolerably regular, instead of being simply quadrate; while the intercalated veins are all connected at their base, instead of being free. Xenoneura also, as compared with modern Sialina, shows what should perhaps be deemed a higher (or at least a later) type of structure, in the amalgamation of the ex-

ternomedian and scapular veins for a long distance from the base, and in the peculiar structure and lateral attachments of the internomedian veins: in the minuter and feebler cross venation, however, it has an opposite character.

12. *We appear, therefore, to be no nearer the beginning of things in the Devonian epoch, than in the Carboniferous*, so far as either greater unity or simplicity of structure is concerned; and these earlier forms cannot be used to any better advantage than the Carboniferous types in support of any special theory of the origin of insects. All such theories have required some Zoæa, Leptus, Campodea, or other simple wingless form as the foundation point; and this ancestral form, according to Hæckel at least, must be looked for above the Silurian rocks. Yet we have in the Devonian no traces whatever of such forms, but on the contrary, as far down as the middle of this period, winged insects with rather highly differentiated structure, which, taken together, can be considered lower than the mass of the Upper Carboniferous insects, only by the absence of the very few Hemiptera and Coleoptera which the latter can boast. Remove those few insects from consideration (or simply leave out of mind their future development to very distinct types), and the Middle Devonian insects would not suffer in the comparison with those of the Upper Carboniferous, either in complication or in diversity of structure. Furthermore, they show no sort of approach toward either of the lower wingless forms, hypothetically looked upon as the ancestors of tracheate Articulata.

13. *Finally, while there are some forms which, to some degree, bear out expectations based on the general derivative hypothesis of structural development, there are quite as many which are altogether unexpected, and cannot be explained by that theory, without involving suppositions for which no facts can at present be adduced.* Palephemera and Gerephemera are unquestionably insects of a very low organization related to the existing may-flies, which are well known to be of inferior structure, as compared with other living insects; these may-flies are indeed among the most degraded of the sub-order to which they belong, itself one of the very lowest sub-orders. Dyscritus too may be of similar degradation, although its resemblance to Homothetus leaves it altogether uncertain. But no one of these exhibits any inferiority of structure when compared with its nearest allies in the later Carboniferous rocks, and they are all higher than some which might be named. While of the remaining species it can be confidently asserted that they are higher in structure than most of the Carboniferous types, and exhibit syntheses of character differing from theirs. It is quite as if we were on two distinct lines of descent when we study the Devonian and the Carboniferous insects; they have little in common, and

each its peculiar comprehensive types. Judging from this point of view, it would be impossible to say that the Devonian insects showed either a broader synthesis or a ruder type than the Carboniferous. This of course may be, and in all probability is, because our knowledge of Carboniferous insects is, in comparison, so much more extensive; but, judging simply by the facts at hand, it appears that the Carboniferous insects carry us back both to the more simple and to the more generalized forms. We have nothing in the Devonian so simple as Euephemerites, nothing so comprehensive as Eugereon, nothing at once so simple and comprehensive as Dictyoneura. On the derivative hypothesis, we must presume, from our present knowledge of Devonian insects, that the Palæodictyoptera of the Carboniferous are already, in that epoch, an old and persistent embryonic type (as the living Ephemeridæ may be considered to-day, on a narrower but more lengthened scale); that some other insects of Carboniferous times, together with most of those of the Devonian, descended from a common stock in the Lower Devonian or Silurian period; and that the union of these with the Palæodictyoptera was even further removed from us in time;—carrying back the origin of winged insects to a far remoter antiquity than has ever been ascribed to them; and necessitating a faith in the derivative hypothesis, which a study of the records preserved in the rocks could never alone afford; for no evidence can be adduced in its favor based only on such investigations. The profound voids in our knowledge of the earliest history of insects, to which allusion was made at the close of my paper on the Early Types of Insects, are thus shown to be even greater and more obscure than had been presumed. But I should hesitate to close this summary without expressing the conviction that some such earlier unknown comprehensive types as are indicated above did exist and should be sought.

ART. XII.—*On the Meteoric Iron of Lexington County, South Carolina;* by CHARLES UPHAM SHEPARD, Emeritus Professor of Natural History in Amherst College.

THE mass here described was sent in May last by the farmer on whose land it had been found (through the hands of the Hon. N. A. Meelze) to the State Commissioner of Agriculture, Col. A. P. Butler, for examination, and by the latter it was forwarded to Prof. C. U. Shepard, jr., professor of chemistry in the Medical College at Charleston. It was immediately reported upon as meteoric iron. The finder had supposed it to

be a valuable ore, and that it indicated a mine upon his property. On learning its true character he relinquished the idea and was willing to allow Prof. Shepard to become its purchaser.

Its weight as first found was ten and a half pounds. Its figure was oblong or that of a cylinder with two flattened edges and somewhat compressed at the ends; on the whole, approaching most nearly to the shape of a very transverse fresh-water bivalve. Unlike many of the iron masses found in the soil, the surface of the present iron is nearly free from yellow hydrated peroxide of iron, being mostly enveloped with a black and brittle coating, which, though containing some turgite, is yet mostly formed of magnetite. The general surface is smooth, though presenting a few broad but shallow depressions. A series of amygdaloidal masses of troilite, the largest having the size of filberts, traverses the body near the end which has been sliced, and where they were so abundant as to constitute for a considerable space nearly one-third of the aggregate, while elsewhere they scarcely come into view, except in remote isolated amygdules. Where the scaly coating of magnetite is thin or wholly wanting a coarse crystalline structure appears, but without any very continuous lamination. The slicing is not difficult unless the saw encounters troilite or magnetite, the latter of which, associated with traces of graphitoid, envelopes the former and also exists elsewhere in the immediate vicinity of the amygdules, in a coarse net-work of veins. The existence of these seams occasionally aids in the separation of small fragments of the iron, between whose layers it seems to have insinuated itself and acted as a rupturing force. This circumstance seems worthy of notice here, as one of the causes of the disintegration and detonation of meteorites while traversing our atmosphere.

The most interesting feature by far, of the Lexington iron, is that of its remarkable analogy in structure and composition with the Bohumilitz iron, found in 1829, and now preserved in the Bohemian National Museum of Prague, of which a description is given by Dr. Otto Buchner in his catalogue of meteoric collections, page 158,* and still further in the memoir on meteorites, of Prof. Gustave Rose, in the transactions of the Royal Academy of Berlin, 1863.†

The resemblance of the etched surfaces of these irons is so strong that they might very easily be confounded together. They are the only two irons which strikingly give the *moiré*

* Die Meteoriten in Sammlungen, ihre Geschichte, mineralogische und chemische Beschaffenheit, von Dr. Otto Buchner. Leipsic, 1863.

† Beschreibung und Eintheilung der Meteoriten auf grund der Sammlung im mineralogischen Museum zu Berlin, von Gustave Rose, aus den Abhandlungen der Königl. Akadamie der Wissenschaften zu Berlin, 1863, mit vier Kupfertafeln. Berlin, 1864.

métallique luster. The chief difference between the two consists in the thickness of the crystalline bars, which in the Lexington iron is nearly double that in the Bohumilitz. In both, their walls, or bounding sides, are alike broadly undulatory or wavy; and the included spaces are filled with closely crowded points of rhabdite (Rose) and extremely minute lines of tænite (Reichenbach), crossing each other at all angles from 90 to 150°, for the distinct observation of which, however, a lens is requisite. Instead of the usually bright edges of the tænite layers, as they occur within the bars, one sees only bright furrows or channels,—the rhabdite constituting the elevated portions of the surface, evincing its greater passivity under the action of the acid in the process of etching. Indeed, the tænite laminæ, including the bars, have, from the same cause, been similarly depressed below the general surface, though not to such a degree as to conceal their glittering edges. Whether the degree of corrosion in these different constituents of the iron is referable to a difference in their chemical composition, or is simply dependent upon a diversity of crystalline structure, it is impossible to decide. It should here be added that in passivity it far surpasses any iron hitherto discovered. Schreibersite occurs in small quantity along with the graphitoid and magnetite that form enveloping wrappers around the amygdules of troilite; also in short veins and gashes that may be detected here and there on broad polished surfaces of the iron.

The Lexington iron shows no signs of chemical alteration by exposure to the air, in which respect, also, it agrees with that from Bohumilitz.

The specific gravity of the entire mass was 7, that of homogeneous fragments, 7·405. Specific gravity of troilite, 4·77.

The analysis was made by Prof. C. U. Shepard Jr., from cuttings obtained in the division of the iron in such a way as not to include portions of the pyritic nodules. The following result was found:

Iron (with traces of manganese)	92·416
Nickel	6·077
Cobalt	0·927
Insoluble matters	0·264
	99·684

With traces of tin and phosphorus.

New Haven, Nov. 17, 1880.

ART. XIII.—*An attempt to calculate approximately the date of the Glacial era in Eastern North America, from the depth of sediment in one of the bowl-shaped depressions abounding in the Moraines and Kames of New England;* by G. FREDERICK WRIGHT.

[Read at the meeting of the American Association for the Advancement of Science, in Boston, Aug., 1880.]

FOLLOWING the suggestions of Mr. Clarence King, made to the writer four years since,* Mr. Warren Upham traced a terminal moraine of the Continental ice sheet, through Cape Cod from east to west, connecting by the Elizabeth Islands with the back bone of Long Island at Montauk Point, and continuing to Brooklyn, N. Y. From this point across Staten Island and through New Jersey to Belvidere, Professors Cook and Smock have explored it.†

Professor Geo. H. Stone, Mr. Upham and myself have explored and extensively mapped the "Kames" or "Eskers" of New England, which prove to be accumulations of gravel marking the course of the streams which, toward the close of the Glacial period, poured southward toward the sea, independent in large degree of the present water-courses.‡ A striking feature of both the terminal moraine and the kames is the numerous bowl-shaped depressions occurring in them, which Dr. Edward Hitchcock § described as "mere holes, not unfrequently occupied by water," but which could not have been formed by running water. In Wisconsin these are called kettle holes, from their resemblance to a potash kettle, and were first described and correctly explained by Col. Charles Whittlesey of Cleveland, O.‖ Professors N. H. Winchell and Chamberlin have since been industriously marking their extent as they occur in the so-called Kettle Range in Wisconsin. The most satisfactory explanation of these "holes," in my view, is that they mark places where masses of ice were buried in the debris of sand and gravel brought down by the streams of the decaying glacier, and where, upon the melting of the buried ice, a cone-shaped depression would appear with sides as steeply inclined as the nature of the soil would permit. At any rate there can

* See Proceedings of the Boston Society of Natural History, vol. xix, pp. 60–63.

† See Annual Reports of the Geological Survey of New Jersey for 1877 and 1878.

‡ For the observations upon which these statements are based, see Index of Geol. Report of N. H., vol. iii, under "Kames," communications of the author in Proceedings of Bost. Soc. Nat. Hist., vol. xix, pp. 47–63, and xx, pp. 210–220, also a paper read by Professor Stone at the American Association for the Advancement of Science in 1880.

§ See Transactions of Am. Assoc. of Geol. and Nat. for 1841 and 1842, p. 191.

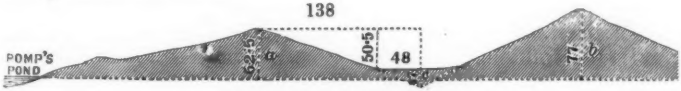
‖ See the Smithsonian Contributions to Knowledge for 1866.

be no question that they were formed about the close of the Glacial period.

It occurred to the writer, some years ago, that these holes might be made to do service in estimating the date of the Glacial era. The results are not so definite as could be wished and from the nature of the case perhaps investigations in this line can never be wholly satisfactory. Still, where every attempt at chronological accuracy has been unsatisfactory, this may not appear wholly useless.

The depressions of which we speak are of all shapes and sizes, from symmetrical "kettle holes" to ponds and lakes of no mean dimensions. It is evident that they cannot always exist, for they are wearing down at the top and filling up at the bottom. For the same reason we know they cannot always have been in existence. As typical of numberless others which appear in the kames I present facts concerning one near Pomp's Pond in Andover, Mass.

Pomp's Pond is one of the moraine basins to which we have referred, and is about a quarter of a mile in diameter and but slightly above the level of the Shawshin River into which it empties. Upon its north side is an accumulation of gravel and sand with pebbles intermingled, in which there are several of the smaller characteristic bowl-shaped depressions of which we have spoken. Their appearance is much like that of volcanic craters. You ascend a sharp declivity from every side to a rim of gravel and then descend as rapidly into the bowl-shaped, or crater-like, depression. A section carried across will present the idea.



Section of "Kettle Hole."

From the level of the pond, and two or three rods from the edge, you begin to ascend at an average rate of about one foot in three till the south side of the rim is reached at a height of $52\frac{3}{10}$ feet above the pond. (This rim is not, however, of a uniform height. On the east side it rises into a pyramid $77\frac{7}{10}$ feet high). Then descending $50\frac{5}{10}$ feet vertically you are carried 138 feet horizontally, reaching at that point the edge of a circular mass of peat which is 96 feet in diameter. From the opposite side, the ascent of the northern rim begins and you descend from its top to the valley, repeating almost exactly the first ascent and descent from the pond. The distance from rim to rim, or the diameter, is 380 feet.

Thus it is evident that since the first formation of this crater-like depression no material can have reached the bottom

except from three sources: 1st, the wash from the sides; 2d, the decay of vegetation which grew within the circumference of the rim; 3d, the dust brought by the winds. It is equally evident that what is once in cannot get out.

Now, from the angle of the declivity the original depth of the depression can be approximately estimated. If the angle be still the same as at first, the first three terms of the proportion would be 138 : 50·5 : : 48 : 17·5, making the original depth below the present surface of the peat a trifle over 17 5 feet. If, however, we suppose the original slant to have been steeper and the rim higher we can still see that there must have been a limit to the depth. Suppose the rim to have been one-third higher and the slant one-third steeper we then would have in round numbers the proportion 138 : 68 : : 48 : 23$\frac{15}{23}$, making the original depth of the depression nearly 24 feet below the present surface of the peat. From the nature of the material it is impossible that the depression should originally have much exceeded that amount.

Accepting this conclusion, the problem is to determine the time it would require the agencies mentioned above to fill the bottom of this bowl to a depth of twenty-four feet—a cone ninety-six feet in diameter at the base and twenty-four feet to the apex—which would be equal to a depth of only *eight* feet over the present surface.

Let us apply some of the estimates of the date of this period. Mr. J. Geikie, following the lead of Mr. Croll and others who look to astronomical data alone, supposes that the so-called Glacial period, whose marks we now study in these low latitudes, synchronized with the last period of high eccentricity of the earth's orbit, which closed about 80,000 years ago and whose maximum influence must have been exerted about 200,000 or 210,000 years since. But, once in 21,000 years, the astronomical conditions dependent upon the precession of the equinoxes favorable for a glaciation of the northern latitudes, occur, though owing to the present low eccentricity of the earth's orbit this influence is now at its minimum.

The question arising in connection with the crater-like depressions I have described is: Could this have stood with so little change for 80,000 years? or even for 40,000 years, as C. H. Hitchcock supposes.* Is not the supposition of 10,000 sufficiently extravagant? If the close of the great glacial period be so far back as Mr. Croll and Mr. Geikie estimate, we must believe that detritus would accumulate, in the situation above described, over a surface of the area of the present peat bog only at the rate of one inch in 1,000 years. While, if we put the close of this period back 10,000, the rate of accumula-

* See Geology of New Hampshire, vol. iii, p. 327.

tion would seem to be as slow as our imagination can well comprehend, viz: one inch in 100 years. The slowest rate which Boucher de Perthes calculated for the accumulation of peat over Roman pottery in the valley of the Somme was three centimeters, or a little over an inch, in a century.

These considerations have led me to look with increasing distrust upon the astronomical calculations which are made concerning the Glacial period, unless we may suppose that the moraines of which we have spoken mark the limit reached at the last semi-revolution of the earth's equinoxes about 10,000 years ago. If we are to look for marks of glaciation in the earlier and more extreme period of the eccentricity of the earth's orbit we should go farther south. The glacial detritus in California, where Prof. Whitney has found human remains, may belong to that earlier period. But it is evident that the glacial phenomena of New England are comparatively recent in their origin.

ART. XIV.—*A Remarkable Nugget of Platinum;* by PETER COLLIER, of Washington, D. C.

SEVERAL years ago I came into possession of a nugget of platinum, said to have been found upon land adjacent to the village of Plattsburgh, New York. Upon examination, the nugget was found to be composed entirely of native platinum and chromite disseminated through it. This chromite was black and of a somewhat resinous luster. The dimensions of the nugget were: length 4 cm., width 3 cm., thickness 2¼ cm. Its weight was 104·4 grams. The specific gravity of the entire nugget was 10·446, and an average of three determinations with a pycnometer of small fragments of the native platinum gave 17·35 as their specific gravity.

This indicates the composition of the nugget by weight to be about as follows: chromite 54 per cent, native platinum 46 per cent. The nugget was found to be slightly attracted by the magnet, a fragment weighing ·09 gram being raised by the magnet. The metallic portion, separated as completely as possible from adhering chromite, was dissolved in aqua regia, leaving a slight residue, which was mainly chromite and sand, of only ·74 per cent. The chromite was decomposed by fusion with bisulphate of potassium. Its composition is given as follows:

Cr_2O_3	54·944
FeO	31·567
Al_2O_3	5·690
SiO_2	3·731
CaO	3·405
MgO	·941
	100·278

There appeared in the interstices of the mass a little earth which probably accounts for the above results of analysis. By deducting these impurities the above analysis would be:

Cr_2O_3	63·511
FeO	36·489
	100·000

An analysis of the platinum gave as follows:

Platinum	82·814
Iron	11·040
Palladium	3·105
Iridium	·627
Rhodium	·286
Copper	·397
Alumina	1·953
Lime	·069
Magnesia	·030
	100·321

Owing to the small quantity of the mineral taken for analysis, 1·45 grams, and the difficulty in separation, the above analysis is perhaps not rigidly exact, and in fact the presence of osmium was unmistakable, although its amount was undetermined. The above analysis, however, shows conclusively that the specimen is a genuine nugget of native platinum; and upon an investigation of the person who found the same, it seems established beyond question that his statement is correct, since the mode of its occurrence and the locality is such as to render the statement quite credible.

Several other specimens were said to have been found at the time when this was discovered, but owing to their real value being unknown they were mislaid or lost. A personal examination of the locality shows it to be in a drift deposit which is of considerable extent. Adjacent rocks exposed upon the surface show well-defined glacial scratches, and the bowlders constituting this deposit are mainly from rock not present in place in that immediate locality. The occurrence of the platinum metals in the St. Lawrence valley has long been known, and the presence of extensive deposits of chromite and its mineral-associate, serpentine, in the same general locality is well established, but so far as I can learn this nugget appears to be remarkable not only for its size, but also as an indication of the probable presence of this metal in a locality hitherto unsuspected.

ART. XV.—*Notice of a new Genus and Species of Air-breathing Mollusk from the Coal-measures of Ohio, and Observations on* DAWSONELLA; by R. P. WHITFIELD.

IN the excellent and interesting article entitled "Revision of the Land Snails of the Paleozoic era, with descriptions of new species," by J. W. Dawson, in the November number of this Journal, the author gives a summary of the knowledge possessed up to that time of the shells of this group of mollusks occurring in these formations. The recognition and description of what is supposed to be a similar form from the Devonian formations of New Brunswick adds a feature of great interest to the knowledge already possessed.

At the time the above mentioned article appeared, I was at work on a new form, the representative of a new genus of the Pupidæ, from the Coal-measures of Ohio, in connection with the preparation of material for the next volume of the Paleontology of that State, and had commenced an examination of the other species, for which purpose I wrote to Professor Dawson to obtain specimens of *P. vetusta;* when he called my attention to the article above mentioned, where I found the work already so admirably done for me.

The form from Ohio is so entirely distinct from any and all of those previously described, although, like them, of minute size, that I have concluded to call immediate attention to it.

The general form of the shell is similar to that of the group of the Pupidæ usually referred to the genus *Vertigo;* minute shells with a nearly vertical aperture, armed with several projecting tooth-like points within its cavity. The shell in question presents these same features with the additional character of a small, nearly circular notch in the peristome, near the upper end of the outer lip, very closely resembling the minute pore-like notch occurring near the upper angle of the aperture in the genus *Pupina* Vignard; or that seen in *Anaulus* Pfeiffer. This latter feature is not present, so far as I am aware, in any genus of inoperculated pulmoniferous shells; at least not in the same degree nor with the same apparent purpose that it occurs in the operculated genera above mentioned. Moreover the last whorl is contracted or flattened on the back in a very similar manner to that of Pupina. It would therefore almost seem that in this little shell of this early age is foreshadowed features of both of these great groups of a later time. The projecting teeth within the aperture as hereafter described would preclude the possibility of an operculum. Taking into consideration these anomalous features I have considered it entitled to rank as the type of a distinct genus,

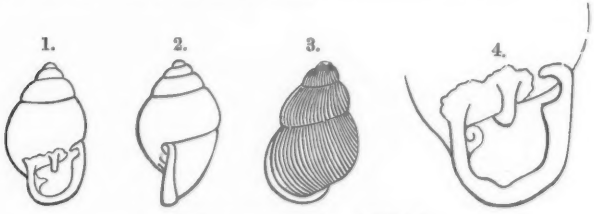
and propose the name *Anthracopupa*, with the following characters.

ANTHRACOPUPA, new genus.

Shell minute, pupaform, with few volutions, the last one unsymmetrical; axis imperforate; aperture large, nearly vertical; peristome thickened, united above by a thin callus on which may occur one or more palatal teeth; other tooth-like projections occur on the inner margin of the lip, and a small, nearly circular notch, resembling that in *Pupina*, deeply indents the inner edge of the outer limb near its junction with the body whorl. Surface of the shell marked by fine, nearly vertical lines. Type *A. Ohioensis.*

ANTHRACOPUPA OHIOENSIS, n. sp.

Shell small and robust, having a length of about three and one-third mm. with a transverse diameter of about two mm. and consisting of about four volutions, the last one extremely ventricose except on the outer half, where it is obliquely flattened and contracted, and, with the aperture, forms about three-fourths of the entire length of the shell. Aperture large, longer than wide, and broadly rounded at the base; lip



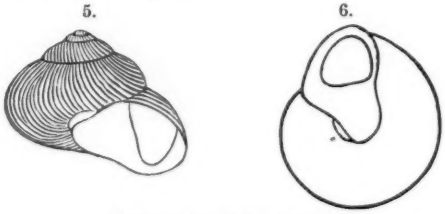
Anthracopupa Ohioensis Whitf.

Fig. 1, view of the aperture; 2, lateral view to show the thickened lip; 3, back view, showing lip and striæ; 4, aperture more enlarged. Figs. 1–3 enlarged six times.

thickened, rounded within and forming a flattened, thickened rim on the outside, particularly on the lower part. Labial notch situated very near the upper extremity of the lip, regular in shape, and forming nearly two-thirds of a circle. A single tooth-like ridge of moderate size extends inward from the lip at about the middle of the columellar side, and another of greater size projects nearly vertically from the middle of the callus which coats the body of the volution within the aperture. Umbilical chink small. Surface of the shell marked by fine, nearly vertical, even striæ or lines. Apex apparently mamillated.

Formation and locality.—In the higher beds of the Coal-measures, near Marietta, Ohio.

In making the studies of the afore-mentioned shell, I obtained from John Collette, Esq., State Geologist of Indiana, specimens of *Pupa Vermilionensis* and *Dawsonella Meeki* Bradley. I find that the latter shell has the aperture much contracted by the thickening of the lip on the inside, and against the body volution by a thickened callus coating the volution and almost concealing the umbilicus, while it straightens that margin of the aperture. These features contract the aperture to a very small part of what it must have been before the callosity was formed, while the surface of the callus is slightly concave from side to side, over the distance between the umbilicus and the margin of the aperture. The form of this callus, especially when taken in connection with the thickening of the inside of the lip, has so much resemblance to the corresponding parts of Helicina, that I cannot but come to the conclusion that Dawsonella was an operculated shell, although in the rock in which they are found I have sought in vain for anything resembling an operculum. In the article quoted above, the author shows the extent of this callus in his figure 13 on page 412, and it is well shown in the accompanying outlines.



Dawsonella Meeki Bradley.

Figs. 5 and 6, profile and basal view of *Dawsonella Meeki* Brad., to show the form of aperture and callus resembling that of Helicina.

Pupa vetusta and *Pupa Vermilionensis* are both accompanied in the material in which they are found, by small helicoid shells, which have been described under the generic name *Dawsonella*. The present species is not known to have any such associate; but on the other hand, like the first specimen of *P. vetusta* found, is accompanied in one of the layers in which it occurs, by immense numbers of what appears to be a species of Spirorbis, which is so abundant that a small hand specimen from which two of the *Anthracopupas* were taken, seems to be nearly half composed of it. The form of these Annelid shells is that common in most species of the genus. They have a diameter of nearly one line, and although now packed together in the shale promiscuously, one surface is generally more or less flattened as if through attachment to some foreign body; and they have, I presume, been attached

to marine plants from which they have fallen, as they were decomposed, and have thus been amassed on the muddy bottom. This species I propose to designate by the following name; and illustrations of it will be given in the Paleontology of Ohio, vol. iii.

SPIRORBIS ANTHRACOSIA, n. sp.

Shell minute, planorbiform, composed of from one to two and a half volutions, tube slender, and very gradually increasing in diameter, marked by very fine, irregular, encircling striæ, which are often gathered into little knots or points near the border of the open umbilicus. Lower side of the shell more or less flattened as if for attachment to some foreign substance. Diameter seldom exceeding one line, generally less.

Formation and locality.—In the higher strata of the Coal-measures, near Marietta, Ohio; associated with *Anthracopupa Ohioensis.*

ART. XVI.—*Hiddenite, an Emerald-green variety of Spodumene;* by J. LAWRENCE SMITH, of Louisville, Ky.

THE new variety of spodumene described in this paper was discovered about five years since on the farm of Mr. Warren, in Alexander County, North Carolina, one of the western counties of the State, which counties have furnished within a few years so many interesting minerals, including the samarskite. Shortly after its discovery some crystals came into the hands of Mr. Stephenson of Statesville, the best of which he sent to Mr. N. Spang of Pittsburgh. Subsequently he showed others of them to Mr. W. E. Hidden, a very enterprising collector of the minerals of this region, and from him I obtained all the specimens examined, as well as my information in regard to their mode of occurrence. The crystals were first found very sparingly, and loose in the soil, but Mr. Hidden, having leased the locality and carried on a systematic exploration, has discovered the mineral *in situ*, and obtained many fine crystals.

Up to the time when my attention was called to the mineral it was considered *diopside*, a reasonable conclusion considering the imperfect character of the crystals that had been found. A blowpipe test, and a determination of its specific gravity showed me that it was not diopside, but an unusual variety of spodumene.

Mode of occurrence.—In the absence of any drift formation in this region it is evident that all the minerals found here detached and loose in the soil—as most of them are—were

furnished by the rocks beneath. The soil has been formed by the decomposition of these rocks, and surface washings have caused only small displacement of the mineral from its original locality. The rocks are metamorphic and are mostly gneiss and mica schist.

The vein bearing the spodumene crystals runs almost due east-and-west across the bedding, and dips at an angle of 70°. It is only a few inches wide and two feet in lateral extension, being in fact a kind of chimney. There are other similar veins in the vicinity, but it is only in this one that the crystals have yet been found. The walls of this contracted vein contain crystals of quartz, mica, rutile, beryl and orthoclase. The beryls are very fine, and may yet be found sufficiently colored to be valuable as gems. The vein does not come to the surface but commences about eight feet below it, as a narrow seam of hard kaolin, and in this kaolin lies the spodumene; the vein so far as yet explored having undergone alteration. One end of the crystals is almost invariably broken; but they are sometimes imbedded in quartz crystals and are perfect in form; others occur attached to the sides of the quartz. The vein has been worked to a depth of twenty-three feet, without any material change in its character.

Color.—The mineral, which is always transparent, ranges in color from colorless (very rare) to a deep emerald green; sometimes the entire fragment has a uniform green color, but generally it is more intense at one of the extremities.

Crystallization. — The crystals are very frequently twins, rarely *fourlings*. They are often terminated at one extremity, but the planes are dull and curved, so that good measurements cannot be made. Sometimes single crystals are terminated by the planes $2\text{-}\grave{\imath}$ only, but the planes 2, $2\text{-}\grave{\imath}$ and O are common. The prisms $i\text{-}i$, I and $i\text{-}\bar{2}$ are common and deeply striated. The crystal which is supposed to be a fourling has two sharp projecting edges in the termination, crossing each other. The largest crystal yet found is $2\frac{1}{4}$ inches in length but very thin; the average size is about half an inch long by three-sixteenths thick.

Professor E. S. Dana has kindly furnished me with additional observations, made on some imperfect crystals, which I add here. "The crystals occur in slender prismatic forms, showing in the prismatic zone the two pinacoid planes, also $i\text{-}\frac{3}{2}$, I, $i\text{-}2$, $i\text{-}3$; in this zone the crystals are deeply striated, and are flattened in the direction of the inclined lateral axis. The terminal planes are uniformly rough and uneven, so much so that no satisfactory determination of their symbols can be made; they often form an edge, as the continuation of the front prismatic edge and this is rounded over the whole top of the

crystal. Some of the crystals are twins with the orthopinacoid as the composition-face. An interesting feature of the crystals is the occurrence of *depressions* in the prismatic planes *I*, both the natural planes and those due to cleavage. These figures are shaped something like a sharp wedge; they are inclined at a small angle to the front prismatic edge and in an inverted position to that behind. In the twin crystals, however, they point upward both in the front and behind, in consequence of the inverted position of the other half of the crystal. Great numbers of these figures are sometimes seen, occasionally very minute and much crowded together. The prismatic cleavage is remarkably perfect, yielding surfaces of the highest luster."

The hardness across the crystal is equal to that of the emerald and on the prismatic faces from 6·5 to 7. The specific gravity, as taken from various good specimens, varies from 3·152 to 3·189.

Its behavior before the blowpipe is the same as that of other forms of spodumene. When heated to redness in the flame but not fused, it loses its color, but on cooling regains it—a reaction analogous to that afforded by the emerald. I have as yet in vain sought for the cause of the color. I have employed all the necessary care in examining for chromium, but have found no indication of its presence. In an examination made for vanadium, the result of an experiment with two grams of green material was lost. This behavior in the flame—losing its color, and recovering it again on cooling—belongs as well to chromium as to vanadium.

Composition.—A careful analysis yielded me the following results:

Silica	64·35
Alumina	28·10
Ferric oxide	0·25
Lithia	7·05
Soda	0·50
Loss by heat	0·15
	100·40

The specimen analyzed was of the paler variety. There is a trace of potash in the soda.

The crystals when cut and polished resemble the emerald in luster, though the color is not so intense as in the finest variety of the latter gem. There is reason to hope that further explorations may bring to light crystals of a size and beauty that will make them valuable as gems, and for this reason I have thought it proper to give this variety of spodumene a distinct name. I therefore propose the name of *Hiddenite*, after the indefatigable mineral explorer who has directed our attention to it.

ART. XVII.—*Remarks on the Genus Obolella;* by S. W. FORD.

THE genus *Obolella* was founded by Mr. Billings, in 1861, upon three small Linguloid species, namely *O. chromatica* from the north shore of the Straits of Belle Isle, *O. crassa* from Troy, N. Y., and *O. polita* from the Potsdam sandstone of Wisconsin, —*O. chromatica* being selected as the type. Although at that time the structure of these shells was very imperfectly known, enough had yet been seen, as Mr. Billings informs us, to convince him that the genus was a new one; but it was not until ten years afterward (Canadian Naturalist, December, 1871), that the number of muscular impressions characterizing it was correctly given. In a subsequent paper,* Mr. Billings contributed still further to our knowledge of the genus by his account of the structure of *O. chromatica*, and I hope, in the present article, to offer some additional facts bearing in the same direction, derived mainly from the study of another species, the *O. crassa*. The principal facts with regard to the structure of this species may be stated as follows:

The shell of *Obolella crassa* is suborbicular, with the beak of either valve extending slightly beyond the peripheral contour.

Obolella crassa Hall, sp.

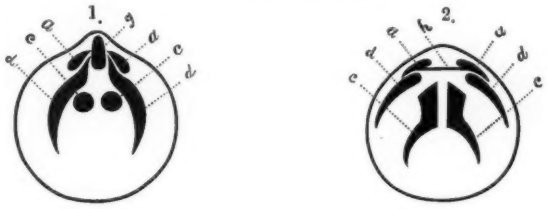


Fig. 1.—Diagram of the interior of the ventral valve of *O. crassa*, enlarged two diameters. Fig. 2.—Diagram of the interior of the dorsal valve, enlarged to the same degree. The specimens are from the original locality of the species, Troy, N. Y.

As a rule, the beak of the dorsal valve is curved downward so as to almost touch the short, indistinct hinge-line, while that of the ventral valve is less depressed and slightly more projecting; and these are the only features by which the two valves may be externally distinguished. The majority of the specimens of the ventral valve have an extremely shallow depression running from the beak to the anterior margin along the median line; but I have found that even this is not distinctive, inasmuch as some of the dorsal valves exhibit it. The specimens

* This Journal for March, 1876.

in my possession vary in length and breadth from one and one-half to six lines, the two diameters being generally nearly equal. The surface of both valves, when perfect, is both radiately and concentrically striated. The shell is thick and solid, showing no tendency to break up into successive laminæ on weathering. I have had portions of it ground and polished for microscopic examination, but am unable to make out any definite structure.

In the interior of the ventral valve, there are two small, ovate muscular scars, situated close to the beak, one on either side of the pedicle groove *g;* and immediately in advance of these a pair of large, elongate, curved scars, which sometimes extend forward into the anterior fourth of shell. Between these latter, and somewhat above the mid-length of the valve, there are two small subcircular impressions. All of these scars are, in well preserved specimens, deeply impressed, and, taken together, constitute a conspicuous and beautiful system. There is usually a distinct ridge running along the middle of the large lateral impressions, dividing them at bottom into two portions; and in some cases its wider, upper portion, is minutely pustulose. The rostral portion of the valve is often much thickened, the several scars bounding the elevation. The interior surface of the forward portion of the valve is marked by fine radiating striæ.

The dorsal valve possesses a small though distinct area, which is divided into two equal portions by a feeble longitudinal ridge. The slender cardinal line is delicately notched in the middle, and has immediately in advance of it a deep transverse groove (fig. 2, *h*). On either side of the longitudinal ridge referred to, there is a small, ovate, cardinal muscular scar. These scars have their apices directed downward and outward, their upper portions cutting across the extremities of and limiting the cardinal line. Directly in front of the cardinals there are two larger impressions of similar shape and direction, the laterals, which extend forward to the mid-length of the shell. These two pairs of impressions are frequently connected with each other, by the cardinals passing down into the laterals; but, as will be seen, they are not so connected in the specimen figured, which has been selected in order to illustrate more clearly their essential independence. In the central portion of the valve there is a pair of still larger impressions (*c c*), having their upper portions parallel, and their lower, falcate parts, widely diverging. Between their parallel portions there is a low mesial ridge, which dies out before reaching the hinge-line. The falciform portions of these scars are, in general, very faintly impressed, and might readily escape observation. The interior surface is usually smooth.

If we compare the interior of *O. crassa* with that of *O. chromatica*, illustrations of which are herewith introduced (figs. 3 and 4), we shall find that, while there are some notable differences, the plan in each is the same. The principal differences

3. 4. 5.

Fig. 3.—Plan of the interior of the ventral valve of *O. chromatica* as made out by Mr. Billings; Fig. 4.—Ditto of the dorsal. Fig. 5.—Plan of the interior of the ventral valve of *O. gemma* Billings. The notation is the same for all of the figures: *aa*, cardinal, *cc*, central and *dd*, lateral impressions; *g*, the groove in the area; *i*, pit in which the groove terminates.

are (1) that the cardinals of the ventral valve of *O. crassa* have their apices directed inward instead of outward as in *O. chromatica;* (2) that the central scars are not here connected with the laterals; and (3) that the central impressions of the dorsal valve of this species have, as compared with the corresponding impressions of the dorsal valve of *O. chromatica*, an extraordinary development. The upper portions of these scars are, in general, all that can be readily discerned; and, were it not for the fact that the central pair in fig. 4 are situated so far forward, I should be disposed to consider them but parts of larger impressions. But notwithstanding this objection, it is possible that better preserved specimens will show them to have possessed divaricating forward extensions. In fig. 5, we have a form departing still more widely from the type, but the plan of structure, as shown by Mr. Billings, is fundamentally the same.

In his paper on the structure of *Obolella chromatica* already referred to, Mr. Billings includes in his genus, *O. chromatica*, *O. crassa*, *O. polita*, *O. gemma* and *O. nana;* at the same time remarking that, although a number of other species have been referred to it, they are all more or less doubtful. The structural details of *O. polita* and *O. nana* have not yet been worked out as completely as could be desired, but it is evident that we have here a natural group, and one remarkable for its clearness of definition. It is, further, tolerably evident that such forms as *O. desiderata* Billings, from the Quebec group of Canada, and *O. sagittalis* Salter, from the Menevian group of Wales do not belong to it; neither of them possessing, so

far as known, the characteristic muscular markings of *Obolella*, and *O. sagittalis* lacking, in addition (as shown by the figures of both Mr. Davidson* and G. Linnarsson†), not only an area but a pedicle groove. These differences, to my mind, render it highly probable that *O. sagittalis* will yet be found to constitute a new genus; and if the ventral valve should ultimately prove to possess an area, then the small Brachiopod described by Barrande and Verneuil from the Spanish Primordial‡ may possibly represent it. Unlike *Obolella*, the apex of the ventral valve in both of these species, is occasionally minutely perforated. The interior of the Spanish species is unknown, but its external aspect, apart from the perforation mentioned, is closely like that of an *Obolella*.

At present the genus *Obolella* appears to be restricted to the American Primordial, and to that portion of it which is regarded as higher in position than the *Paradoxides* beds. This horizon presents, under its life aspects, a number of features of unusual interest, some of which I purpose, hereafter, to make the subject of critical review.

I have presented the foregoing observations at this time, partly for the purpose of directing the attention of paleontological workers still more strongly to the interesting genus under notice; and partly in the hope that they may possibly contribute something looking toward a better understanding of the foreign species spoken of, both of which occur low down in the Primordial Zone.

December 10th, 1880.

Art. XVIII.—*The Millstone Grit in England and Pennsylvania;* by H. Martyn Chance.

A lately published report on the "Geology of the Yorkshire Coalfield," by Professor A. H. Green and his associates, contains a description of the Millstone Grit which is of more than passing interest to those familiar with this formation in Pennsylvania and Ohio.

A survey of the Conglomerate, No. XII (Millstone grit), made in 1875 along the Beaver and Shenango valleys, led me to conclude that that rock in Western Pennsylvania is a composite series of sandstones and conglomerates separated by shales and slates with interbedded coals, limestones, iron ores and fire clays, with a total thickness of 250–325 feet (Report V,

* Monograph of British Silurian Brachiopoda, p. 339, pl. 50, figs. 1–14, (1871).

† On the Brachiopoda of the Paradoxides beds of Sweden, p. 19, pl. iii, figs. 36–41, (1876). Idem, "Om Faunan i kalken med Conocoryphe Exsulans," p. 27, pl. iii, figs. 45–49, (1879).

‡ Bull. Soc. Geol. Fr., vol. xviii, p. 536, pl. VIII, figs. 5*a–e*.

Geol. Survey of Pa., 1879). The same conclusion was simultaneously reached by Mr. Carll in the oil regions (Reports I and III) and afterwards by Professor White in his reports on the Ohio line counties (Q, QQ, QQQ); and it now appears that Professor Green and his colleagues were at the same time working out a strikingly similar structure in this rock in the Yorkshire district. The nomenclature first adopted by these geologists is compared in the following table with that adopted by Professor White and myself:

Yorkshire.	Pennsylvania.
"Rough Rock."	Homewood Sandstone.
Shales (sporadic coals).	Mercer coal group.
"Second Grit."	Connoquenessing Upper Sandstone.
Shales (coal).	Quakertown coal.
"Third Grit."	Connoquenessing Lower Sandstone.
Shales (coal).	Sharon coal.
"Kinder Scout Grit."	Sharon (or "Ohio") Conglomerate.

Over large areas this nomenclature is easily and naturally applicable to all vertical sections in both Yorkshire and Western Pennsylvania, but at some localities the English "Second" and "Third" grits and the Connoquenessing sandstones are represented by one or by several (four or five) rocks, and it was therefore found necessary to generalize the Yorkshire scheme by including these in one subdivision under the name "Middle Grits," thus: (Geol. of Yorkshire, p. 32).

Millstone Grit {
"Rough Rock or Topmost Grit.
Shales.
Middle Grits.—A group of sandstones and shales, variable in number, thickness and character.
Shales.
Kinder Scout or Lowest Grits."

In Western Pennsylvania a precisely similar generalization has been resorted to (Report V, pp. 188 and 223), thus:

Conglomerate, No. XII {
Homewood Sandstone.
Mercer Group,—coals, etc.
Connoquenessing Group,—sandstones.
Sharon Group.
"Ohio" or Sharon Conglomerate.

The Homewood Sandstone is a hard, massive conglomeritic rock; the Rough Rock is also of this type and is used as a key-rock just as the former has been used in Pennsylvania. The Kinder Scout Grit is hard, massive, coarse and often conglomeritic, and is also used as a key-rock; while in Pennsylvania the Sharon Conglomerate (or Olean, Garland or Meadville rock) has likewise been a most valuable guide. It is usually hard and massive and often a true conglomerate. When capping the hilltops it forms prominent "rock cities."

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On an Improved Process for preparing Potassium Iodide from Seaweed.*—Allary and Pellieux have devised an improved process for extracting potassium iodide from the ashes of seaweed. The mother liquors, obtained in the preparation of potassium chloride and sulphate from these ashes, are evaporated to dryness in a special air furnace and then carefully roasted in a current of air, to complete desulphurization. The residue is extracted with cold water and the solution is again evaporated to dryness. A white saline residue is obtained containing 50 per cent of iodides. This is pulverized, introduced into a digestor and treated with hot alcohol whereby the iodides are extracted and accumulate in the aqueous lower layers. The alcohol is then distilled off and the solution obtained contains a mixture of two-thirds sodium and one-third potassium iodide. To this is added the necessary quantity of potassium carbonate, in saturated solution, and a current of carbon dioxide gas is passed through the whole. Hydro-sodium carbonate crystallizes out and potassium iodide remains in solution. After exact neutralization of the small remaining quantity of the carbonate by hydrochloric acid, the potassium iodide is crystallized out. For special purposes, it is extracted by alcohol and recrystallized.—*Bull. Soc. Ch.*, II, xxxiv, 627, Dec., 1880. G. F. B.

2. *On the Volumes of certain Elements at their Boiling Points.*—Ramsay has determined the volumes of sodium and bromine at the boiling point, and in connection with Masson, of phosphorus also. The method used for bromine and phosphorus was that previously employed for sulphur.* A glass bulb of known capacity was filled with the liquid substance and placed in a vessel in which more of this substance was boiled. After allowing time for the temperature of the bulb and vapor to become uniform, the bulb was withdrawn and allowed to cool. The weight of substance that it contained was evidently that required to fill the bulb at the boiling point; i. e. to occupy a known volume. Hence the ebullition-volume could be easily calculated. Four determinations made in this manner gave for the specific weight of bromine 2·9503, 2·9474, 2·9483 and 2·9471; for its specific volume 0·3390, 0·3393, 0·3392 and 0·3393; and for its atomic volume 27·12, 27·14, 27·13 and 27·15. Or as a mean, sp. wt. 2·9483, sp. vol. 0·3392, and at. vol. 27·135. The phosphorus was fused in a wide tube in a current of CO_2, and the bulb filled by suction. The phosphorus was boiled on a sand bath, the bulb remaining in the vapor until liquid phosphorus ceased to issue from it. It was then withdrawn and weighed. The mean results were: sp. wt. 1·4850; sp. vol. 0·6734; and atomic volume 20·91 with a proba-

* J. Chem. Soc., xxxv, 463, July, 1879.

ble error of ±0·3987. For sodium, the apparatus was made of iron, though essentially similar in form. After the bulb was filled with liquid sodium it was hung in an iron pot containing 20 grams of this metal, a tight cover having a small opening was fastened on and the whole was heated on a charcoal fire. After boiling for ten minutes, the cover was removed and the bulb plunged into paraffin oil. After cooling it was cleaned and weighed. The sp. wt. thus obtained was 0·7414; sp. vol. 1·3490; at. vol. 31·0. Ramsay calls attention to the fact that bromine and all the halogens probably have but one atomic volume, either when free or in combination. (For free bromine this is 27·135 and for combined bromine 28·1.) Sulphur, like oxygen, has two atomic volumes in combination, 22·6 and 28·6, its atomic volume when free being 21·6. As to phosphorus, since nitrogen has three atomic volumes, one in amines, one in cyanides and nitriles and one in the nitryl group, it is probable that this element has more than one when in combination. Hitherto its atomic volume in combination has been given as 25·3; free as above given it is 20·9. If the oxy- or sulpho-chloride be written with quinquivalent phosphorus $PX\overline{Cl}_3$ or $X{=}PCl_3$ in which X represents a sulphur or an oxygen atom, these atoms are saturating and the atomic volume of the phosphorus in these compounds calculated on this supposition is 20·7. This value agrees with that of free phosphorus. Hence in combination phosphorus has an at. vol. of 20·7 when a pentad and of 25·3 when a triad.—*Ber. Berl. Chem. Ges.*, xiii, 2145, 2146, 2147, Dec. 1880. G. F. B.

3. *On Vanadium Sulphides.*—Kay, under Roscoe's direction, has examined the compounds formed by vanadium and sulphur, particularly those which were described by Berzelius in 1831. He finds that three sulphides exist, having the formulas respectively, of V_2S_2, V_2S_3 and V_2S_5. Vanadium disulphide is formed by passing perfectly pure and dry hydrogen over the trisulphide heated to intense redness. Vanadium trisulphide is formed (1) by passing H_2S over the trioxide at a red heat; (2) by the action of H_2S on any chloride or oxychloride of vanadium heated to redness; (3) by acting on the pentoxide by CS_2 vapor at high temperatures; the latter being the most convenient. Vanadium pentasulphide is formed by heating the trisulphide to about 400° with one-third its weight of sulphur in a long narrow tube. The author finds that Berzelius's products obtained by precipitation were oxycompounds but not of definite composition; but that the sulphide prepared by him in the dry way was the true trisulphide.—*J. Ch. Soc.*, xxxvii, 728, Dec. 1880. G. F. B.

4. *On the Hydrocarbons of American Petroleum.*—Beilstein and Kurbatow, in their research upon the petroleum of the Caucasus,* regarded the facility with which this petroleum was attacked by nitric acid as a proof of the absence of the hydrocarbons C_nH_{2n+2}. To test this conclusion further, and to ascertain exactly the resistance to the action of nitric acid offered by

* This Journal, III, xxi, 67, Jan., 1881.

this series, a portion of heptane, distilling at 95°–100° and of sp. gr. 0·7192 at 15·5°, was prepared from American ligroin. It gave on analysis C 84·3, H 15·4; C_7H_{16} requiring C 84, H 16 per cent. One part of this heptane was heated with four parts of nitric acid (sp. gr. 1·38) so long as red fumes were evolved. From the oily layer above the acid, unattacked heptane was isolated, boiling at 98·5°–99·5°, of sp. gr. 0·6967 at 19°, and yielding on analysis C 84·2, H 15·9. Further action of the nitric acid upon this body was scarcely detectable. These results showed that beside the series C_nH_{2n+2} American ligroin contained hydrocarbons poorer in hydrogen, which the nitric acid removed leaving the heptane pure. The suggestion that these hydrocarbons were the addition-products of the benzene series, as in the Caucasian petroleum, led to an examination; and from some ligroin of boiling point 115°–120° a small quantity of trinitroisoxylene was obtained by the action of nitrosulphuric acid; thus proving the presence of these bodies. In purifying a considerable quantity of crude American heptane by the nitric acid method, there was obtained on subsequent fractioning a product of much higher boiling point which proved to contain nitrogen. It boiled at 195°–200° (after treatment with stannous chloride 193°–197°) and had a gravity of 0·9369 at 19°. On analysis it gave the formula $C_7H_{15}NO_2$. Hence the nitro-product of the American petroleum belongs to the marsh gas series, while that of Caucasian is derived from the ethylene series $C_6H_{11}NO_2$.—*Ber. Berl. Chem. Ges.*, xiii, 2028, Nov. 1880. G. F. B.

5. *On Inulin.*—KILIANI has published a research upon inulin as an inaugural dissertation at Munich. The following are the conclusions of his paper: Inulin stands in the most intimate chemical relation to levulose. It appears to be the anhydride of this body and passes into it with such facility, that in all reactions which require a long warming with water or need the presence of dilute acids, the inulin is replaced by levulose. By nearly all reactions therefore these bodies yield the same products. Inulin is distinguished sharply from levulose, in consequence of a property possessed by the latter in common with the simple sugars, of reducing the copper test and of fermenting under the action of yeast. Inulin neither reduces Fehling's test nor undergoes fermentation. Moreover it does not form hydrogen addition products. Its hydrate, levulose, differs from dextrose in its oxidation-products; the latter affording when oxidized with nitric acid or bromine and water, compounds which contain six carbon-atoms, saccharic (perhaps gluconic) acid; while levulose similarly treated affords bodies with a less content of carbon; glycolic and oxalic acids. This the author explains by supposing dextrose to be the aldehyde of mannite and levulose its ketone. Oxidation of both dextrose and levulose with silver oxide gives glycolic acid; but gluconic acid is probably first formed and then oxidized to glycolic and carbonic acids.—*Liebig's Ann.*, ccv, 145, Nov. 1880. G. F. B.

6. *On Saccharin and Saccharinic Acid.*—SCHEIBLER has examined carefully the new glucose derivative discovered by Peligot and called saccharin, to which he assigned the formula $C_{12}H_{22}O_{11}$. For its preparation dextrose or levulose or a mixture of both may be used. The best material is the solid starch-sugar of commerce. A kilogram was dissolved in 7 or 8 liters of water, the solution heated to boiling and freshly prepared and still warm slacked lime added in large excess. The boiling is continued so long as lime salts separate. It is then cooled, the liquid drawn off with a siphon, freed from excess of lime by carbon dioxide gas, and from combined lime by addition of an equivalent quantity of oxalic acid. The filtrate from this is evaporated to a thick syrup and allowed to crystallize. This may take days, and is hastened by adding a crystal from a previous operation. It is freed from the adhering mother liquor and recrystallized. Its properties confirmed those given by Peligot; but its analysis gave numbers leading to the formula $C_6H_{10}O_5$; carbon 44·26, H 6·32. The author shows that when saccharin is boiled with freshly precipitated calcium carbonate the latter is dissolved with evolution of CO_2, and calcium saccharinate is formed. If, however, the calcium be separated by oxalic acid, saccharinic acid itself is not obtained but splits at once into saccharin and water. To this body saccharin, therefore, Scheibler assigns the structural formula

$$CH_2(OH)-CH(OH)-CH(OH)-CH-CH_2-CO$$
$$\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\quad \diagdown O \diagup$$

The saccharinates are remarkably soluble in water and are uncrystallizable, except those of potassium and ammonium. Optically, saccharin is dextrorotatory, $[\alpha]_D=+93·8$. But the saccharinates are lævorotatory, the calcium salt giving $[\alpha]_D=-5·7$ and the sodium salt $[\alpha]_D=-17·2$. Further researches are in progress.—*Ber. Berl. Chem. Ges.*, xiii, 2212, Dec. 1880. G. F. B.

7. *On the Synthesis of Tropic Acid.*—LADENBURG and RÜGHEIMER have succeeded in effecting the synthesis of tropic acid. By the action of phosphoric chloride upon acetophenone, dichlorethylbenzene was prepared by the reaction:

$$C_6H_5COCH_3+PCl_5=C_6H_5CCl_2CH_3+POCl_3.$$

20 grams of this was put into a solution of 16 grams KCy in 160 grams 50 pr. ct. alcohol and allowed to stand 48 hours. After heating, neutralizing with barium hydrate and filtering, the solution was acidulated, filtered and agitated with ether. This left on evaporation ethyl-atro-lactic acid, which treated with hydrochloric acid gave atropic acid, readily converted into tropic acid.—*Ber. Berl. Chem. Ges.*, xiii, 2041, Nov. 1880. G. F. B.

8. *Experimental Researches upon the magnetic rotatory Polarization of Gases.*—M. HENRI BECQUEREL carefully describes his apparatus and the means taken to eliminate all causes of error in his difficult determinations. A copper tube $0·122^m$ in diameter and $3·27^m$ in length enclosed the gases and this was made the

core of an electro-magnet. By means of mirrors at each end of the tube a ray from a lime light was made to traverse many times by successive reflections the column of air or gas. The principal causes of error arising from the heating of the gas by the strong current traversing the electro-magnet and from the polarization of the glass plates at the ends of the tube were carefully eliminated. The author concludes that the magnetic rotatory powers of bodies are intimately connected with their indices of refraction n, and the variations of the function $n^2(n^2-1)$ are of the same order of magnitude as those of the magnetic rotations of the same bodies in the solid, liquid or gaseous states. The following conclusions are drawn from the investigation.

(1) Bodies in the gaseous state, as well as solid substances and liquids, have the property of deviating the plane of polarization when submitted to magnetic influence.

(2) The magnetic rotations of the plane of polarization of rays of different wave lengths traversing the same gas (oxygen excepted) are generally inversely as the squares of the length of wave of the luminous rays which are considered.

(3) The magnetic rotatory power of gases can be compared to that of liquid sulphide of carbon, and consequently to those of other solid and liquid bodies. A remarkable relation appears to exist between the magnetic rotatory power of gases and their indices of refraction.

(4) Oxygen presents an anomaly which is apparently connected with the exceptional magnetic properties of this gas.—*Annales de Chimie et de Physique*, Nov., 1880, p. 289. J. T.

9. *The influence of Gases and Steam upon the Optical properties of reflecting surfaces.*—It is well known that gases and steam can alter the physical condition of the surfaces of solid bodies even if they do not act chemically upon these surfaces. Herr Glan after careful experiments decides that if the gases do not act chemically upon the substances of the reflecting surfaces and are not condensed in a quantity apparent to the eye, no change of phase takes place in reflection.—*Ann. der Physik und Chemie*, Nov. 11, 1880. J. T.

10. *A Physical Treatise on Electricity and Magnetism;* by J. E. H. Gordon, B.A., Cambridge. 8vo. (D. Appleton & Co., N. Y.) —The treatise of Mr. Gordon is beautifully illustrated with cuts of Sir William Thomson's Electrometers which the student will not find elsewhere. There are also many engravings of other electrical apparatus which one is tempted to criticize as too elaborate; a diagram would have answered in many cases better than the finely finished perspective views, and there would have been more room for solid information. A full page, for instance, is given to an illustration of Mr. Spottiswode's gigantic induction coil, which cut it seems to us is chiefly useful in showing the assistant in the act of discharging the coil. This method of illustrating treatises on science is too much in the manner of the instrument makers' catalogues.

The chapter on inductive capacity is very ample and the student will be repaid by its perusal. The treatise also contains a full account of the late experiments of de la Rue, and of Crookes on electrical discharges in rarefied gases, also of the experiments of Dr. Kerr and others on the magnetic polarization of light. The author evidently desired to do for the physical side of electricity and magnetism what Maxwell has done for the mathematical side of the science. The careful reader of Maxwell's treatise, even if he is not a mathematician, will gain a very good knowledge of the physical side of the subject. Still there are those who are deterred from reading Maxwell on account of the formidable array of mathematical formulas, and to such readers the treatise of Mr. Gordon cannot fail to be very acceptable. J. T.

11. *On the Space protected by a Lightning-Conductor;* by WILLIAM HENRY PREECE.*—Any portion of non-conducting space disturbed by electricity is called an electric field. At every point of this field, if a small electrified body were placed there, there would be a certain resultant force experienced by it dependent upon the distribution of electricity producing the field. When we know the strength and direction of this resultant force, we know all the properties of the field, and we can express them numerically or delineate them graphically. Faraday (Exp. Res., § 3122 *et seq.*) showed how the distribution of the forces in any electric field can be graphically depicted by drawing lines (which he called *lines of force*) whose direction at every point coincides with the direction of the resultant force at that point; and Clerk-Maxwell (Camb. Phil. Trans., 1857) showed how the magnitude of the forces can be indicated by the way in which the lines of force are drawn. The magnitude of the resultant force at any point of the field is a function of the potential at that point; and this potential is measured by the work done in producing the field. The potential at any point is, in fact, measured by the work done in moving a unit of electricity from the point to an infinite distance. Indeed the resultant force at any point is directly proportional to the rate of fall of potential per unit length along the line of force passing through that point. If there be no fall of potential there can be no resultant force; hence if we take any surface in the field such that the potential is the same at every point of the surface, we have what is called an *equipotential surface.* The difference of potential between any two points is called an electromotive force. The lines of force are necessarily perpendicular to the surface. When the lines of force and the equipotential surfaces are straight, parallel, and equi-distant, we have a *uniform field.* The intensity of the field is shown by the number of lines passing through unit area, and the rate of variation of potential by the number of equipotential surfaces cutting unit length of each line of force. Hence the distances separating the equipotential surfaces are a measure of the electromotive force

* From the Philosophical Magazine for December, 1880.

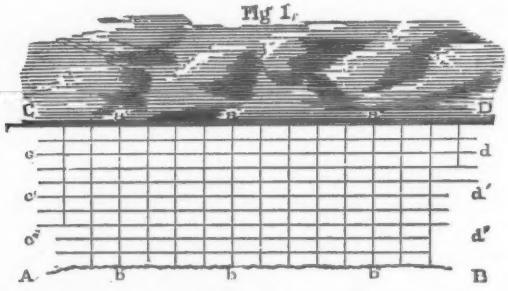
present. Thus an electric field can be mapped or plotted out so that its properties can be indicated graphically.

The air in an electric field is in a state of tension or strain; and this strain increases along the lines of force with the electromotive force producing it until a limit is reached, when a rent or split occurs in the air along the line of least resistance—which is disruptive discharge, or lightning.

Since the resistance which the air or any other dielectric opposes to this breaking strain is thus limited, there must be a certain rate of fall of potential per unit length which corresponds to this resistance. It follows, therefore, that the number of equipotential surfaces per unit length can represent this limit, or rather the stress which leads to disruptive discharge. Hence we can represent this limit by a length. We can produce disruptive discharge either by approaching the electrified surfaces producing the electric field near to each other, or by increasing the quantity of electricity present upon them; for in each case we should increase the electromotive force and close up, as it were, the equipotential surfaces beyond the limit of resistance. Of course this limit of resistance varies with every dielectric; but we are now dealing only with air at ordinary pressures. It appears from the experiments of Drs. Warren De La Rue and Hugo Müller that the electromotive force determining disruptive discharge in air is about 40,000 volts per centimeter, except for very thin layers of air.

If we take into consideration a flat portion of the earth's surface, A B (fig. 1), and assume a highly charged thunder-cloud, C D, floating at some finite distance above it, they would, together

Fig 1.



with the air, form an electrified system. There would be an electric field; and if we take a small portion of this system, it would be uniform. The lines $a\,b$, $a'\,b'$ . . . would be lines of force; and cd, $c'\,d'$, $c''\,d''$ . . . would be equipotential planes.

If the cloud gradually approached the earth's surface (fig. 2), the field would become more intense, the equipotential surfaces would gradually close up, the tension of the air would increase until at last the limit of resistance of the air $e\,f$ would be reached; disruptive discharge would take place, with its attendant thunder

and lightning. We can let the line *e f* represent the limit of resistance of the air if the field be drawn to scale; and we can thus trace the conditions that determine disruptive discharge.

Fig. 2.

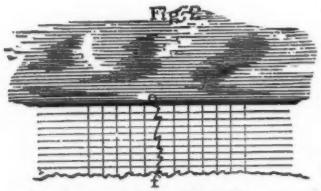
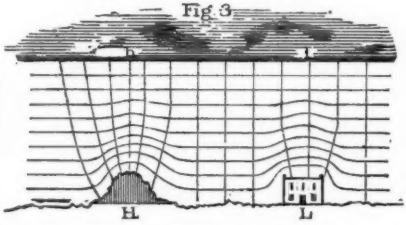


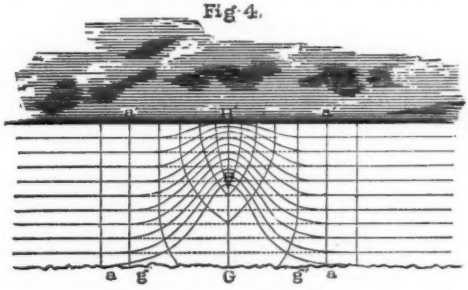
Fig. 3.



If the earth-surface be not flat but have a hill or a building, as H or L, upon it, then the lines of force and the equipotential planes will be distorted, as shown in fig. 3. If the hill or building be so high as to make the distance H *h* or L *l* equal to *e f* (fig. 2), then we shall again have disruptive discharge.

If instead of a hill or building we erect a solid rod of metal, G H, then the field will be distorted as shown in fig. 4. Now it is quite evident that whatever be the relative distance of the cloud

Fig. 4.

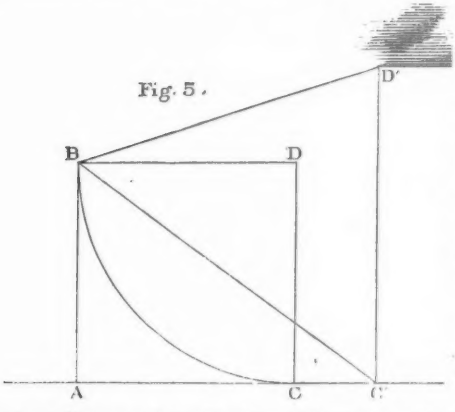


and earth, or whatever be the motion of the cloud, there must be a space *g g'* along which the lines of force must be longer than *a' a* or H H'; and hence there must be a circle described around G as a center which is less subject to disruptive discharge than the space outside the circle; and hence this area may be said to be protected by the rod G H. The same reasoning applies to each equipotential plane; and as each circle diminishes in radius as we ascend, it follows that the rod virtually protects a cone of space whose height is the rod, and whose base is the circle described by the radius G *a*. It is important to find out what this radius is.

Let us assume that a thunder-cloud is approaching the rod A B (fig. 5) from above, and that it has reached a point D' where the distance D' B is equal to the perpendicular height D' C'. It is evident that, if the potential at D be increased until the striking-distance be attained, the line of discharge will be along D' C or

D′ B, and that the length A C′ is under protection. Now the nearer the point D′ is to D the shorter will be the length A C′ under protection; but the minimum length will be A C, since the cloud would never descend lower than the perpendicular distance D C.

Fig. 5.



Supposing, however, that the cloud had actually descended to D when the discharge took place. Then the latter would strike to the nearest point; and any point within the circumference of the portion of the circle B C (whose radius is D B) would be at a less distance from D than either the point B or the point C.

Hence a lightning-rod protects a conic space whose height is the length of the rod, whose base is a circle having its radius equal to the height of the rod, and whose side is the quadrant of a circle whose radius is equal to the height of the rod.

I have carefully examined every record of accident that was available, and I have not yet found one case where damage was inflicted inside this cone when the building was properly protected. There are many cases where the pinnacles of the same turret of a church have been struck where one has had a rod attached to it; but it is clear that the other pinnacles were outside the cone; and therefore, for protection, each pinnacle should have had its own rod. It is evident also that every prominent point of a building should have its rod, and that the higher the rod the greater is the space protected.

12. *A theoretical and practical Treatise on the Manufacture of Sulphuric Acid and Alkali, with the collateral branches;* by GEORGE LUNGE, Ph.D., F.C.S. Vol. III, 422 pp. 8vo. London, 1880 (J. Van Voorst).—The preceding volumes of this very valuable work have been noticed in full in this Journal (vol. xix, 230, and xxi, 70). The early part of the third and concluding volume contains the closing chapters on the soda industry, including a description of the ammonia process, the manufacture of soda from cryolite, and a statement of the applications of soda, with statistics. The two hundred pages following are devoted to bleaching-powder and chlorate of potash; the manufacture of chlorine by different methods, and of bleaching-powders, with other related subjects, are ably and fully treated. The volume closes with one appendix, giving estimates as to the cost of erecting an alkali-works, and a second in which much valuable matter supplementary to the body of the work is included.

II. Geology and Natural History.

1. *The Lava-fields of Northwestern Europe;* by Archibald Geikie, Director of the Geological Survey of Scotland. (Nature, Nov. 4, 1880).—In this paper the purpose of the author is to illustrate the fact that the greatest of igneous eruptions have taken place without the intervention of volcanic vents, and then to show that the lava-fields of northwestern Europe are examples to a large extent of such non-volcanic ejections.

Professor Geikie first observes that the volcanoes of the Mediterranean basin have given to science, as well as the popular mind the prevalent idea as to the features of igneous action—so that "even among those who have specially devoted themselves to the study of volcanoes there has been a tacit assumption * * * that where volcanic outbreaks have occurred it has been from local vents, like those of Etna, the Æolian Islands, the Phlegræan fields, or the Greek Archipelago;" and now, the statement that "the type of volcanic cones and craters has not been, in every geological age, and all over the earth's surface, the prevalent one, that on the contrary * * * it belongs perhaps to a feebler or waning degree of volcanic excitement," "would be received by most European geologists with incredulity if not with some more pronounced form of dissent." When Richthofen published, some twelve years since, about vast areas of lava on the Pacific slope of North America made without the aid of cones and craters, Scrope, in his "Considerations on Volcanoes," "ridiculed what he regarded as 'fanciful ideas' and 'untenable distinctions,' which it was 'a miserable thing' to find taught in mining schools abroad." Professor Geikie speaks of his acceptance at first of his teacher's views; but of his finding, afterward, as he studied the facts connected with the erupted masses of Great Britain, that in truth little light was thrown upon the subject by the modern volcano. There were multitudes of dikes of basalt over a region of 100,000 square miles, from Yorkshire to Orkney and from Donegal to the mouth of the Tay, spreading into basaltic plateaux to the westward in Antrim, Skye, northeastern Ireland and elsewhere, having in some places a thickness of 3000 feet, the origin of whose horizontal or nearly horizontal beds without interstratified tufas he says he attempted again and again to explain, but in vain; and, he adds, "Nor so long as the incubus of 'cones and craters' lies upon one's mind does the question admit of an answer."

The author next recounts the facts which he had himself observed in Western America, and states that these first enabled him to understand Richthofen's descriptions and the basalt-sheets of his own country. From his paragraphs we take the following:

"Never shall I forget an afternoon in the autumn of last year upon the great Snake River lava desert of Idaho. It was the last day of a journey of several hundred miles through the volcanic region of the Yellowstone and Madison. We had been riding for two days over fields of basalt, level as lake bottoms, among the

valleys, and on the morning of the last day, after an interview with an armed party of Indians (it was only a few days before the disastrous expedition of Major Thornburgh, and the surrounding tribes were said to be already in a ferment), we emerged from the mountains upon the great sea of black lava which seems to stretch illimitably westward. With minds keenly excited by the incidents of the journey, we rode for hours by the side of that apparently boundless plain. Here and there a trachytic spur projected from the hills, succeeded now and then by a valley up which the black flood of lava would stretch away into the high grounds. It was as if the great plain had been filled with molten rock which had kept its level and wound in and out along the bays and promontories of the mountain-slopes as a sheet of water would have done." * * *

"Riding hour after hour among these arid wastes, I became convinced that all volcanic phenomena are not to be explained by the ordinary conception of volcanoes, but that there is another and grander type of volcanic action, where, instead of issuing from separate vents and piling up cones of lava and ashes around them, the molten rock has risen in fissures, sometimes accompanied by the discharge of little or no fragmentary material, and has welled forth so as to flood the lower ground with successive horizontal sheets of basalt. Recent renewed examination of the basalt-plateaux and associated dykes in the west of Scotland has assured me that this view of their origin and connection, which first suggested itself to my mind on the lava-plains of Idaho, furnishes the true key to their history." * * *

"No more stupendous series of volcanic phenomena has yet been discovered in any part of the globe than those of northwestern Europe. We are first presented with the fact that the crust of the earth over an area which in the British Islands alone amounted to probably not less than 100,000 square miles, but which was only part of the far more extensive region that included the Faroe Islands and Iceland, was rent by innumerable fissures in a prevalent east-and-west or southeast-and-northwest direction. These fissures, whether due to sudden shocks or slow disruption, were produced with such irresistible force as to preserve their linear character and parallelism through rocks of the most diverse nature, and even across old dislocations having a throw of many thousand feet. Yet so steadily and equably did the fissuring proceed over this enormous area, that comparatively seldom was there any vertical displacement of the sides. We rarely meet with a fissure which has been made a true fault with an upthrow and downthrow side."

The paper gives further details respecting these British ejections, and alludes also to the great basaltic plateaux of Abyssinia and of the Deccan in India; and in the course of his concluding remarks Professor Geikie observes, "I believe that the most stupendous outpourings of lava in geological history have been effected not by the familiar type of conical volcano, but by these less known fissure eruptions."

2. *Volumes of solid and liquid Cast Iron, with reference to the theories of Volcanic action.*—Under the above title Mr. J. B. HANNAY presents, in the Proceedings of the Philosophical Society of Glasgow for January, 1880, the results of experiments on cast iron. He first refers to the view of Messrs. Nasmyth and Carpenter, in their work on the Moon, that fusible substances, with few exceptions, are specifically heavier in their molten state than in the solid, and that, consequently, they expand on becoming solid, which view they sustain by referring to a fact recognized by iron founders, that a mass of solid cast iron dropped into molten iron of the same precise kind will float on it; and whence they draw the conclusions that solidification beneath the earth's crust is a cause of fissuring of the crust, and thus of opening volcanoes; and that the cooling of the same after solidification produces shrinkage, and consequently a wrinkling, or alternate ridges and depressions, over the surface. Mr. Hannay states that in his experiments, spheres of iron three to six inches in diameter were dropped into a bath of the same metal four feet wide and two feet deep. In one of them the sphere sank at first to the bottom, where it could be found by raking the pot; in fifty seconds it came to the surface, having a dull-red temperature; as the temperature increased it floated higher and higher, until it began to melt, when it remained constant but diminished in height, of course, as the sphere melted away. Another trial gave the same results, and the value was found to be constant. In other experiments the balls were fished out when at their maximum temperature; and they showed, by the "tide-mark" left, the exact depth of submergence, and also the relation between the volumes or densities of liquid and solid metal. The result reached is, that, on an average, cast iron expands 5·62 per cent of its volume on solidification. The various experiments proved that the iron *just* floats when at a red heat, which is estimated at 750° to 800°. The linear expansion of a bar of iron up to that temperature was ascertained to be, from four experiments, ·000055, ·000070, ·000050 and ·000065, giving a mean of ·000060 per degree Centigrade. The density of the iron used was 7·214, which decreased to 6·883 at about 800°, and this was the density of the liquid; but as the sphere floated with 5·62 per cent of its volume above the liquid, the density of the solid at its fusing point must have been reduced to at least 6·535. The expression *at least* is used because the iron in the experiments had to be above the fusing point to prevent its freezing while these were in progress, whence the result is under the truth. The facts are shown by Mr. Hannay to set aside the experiments of Mr. Mallet.

In the same volume of Proceedings, Dr. Henry Muirhead gives an account of experiments on the same point by Mr. Joseph Whitby and Mr. T. Wrightson. Mr. Wrightson's earliest experiments are published in the British Association Report for 1879, p. 506. Later results, from a much larger number of experiments on metals, are given in a paper in the "Journal of the

Iron and Steel Institute," No. 11, for 1879. Mr. Wrightson concludes that, in passing from the solid to the liquid state, the density of the iron is greatest when cold, least when in the plastic state, and that when liquid it is between the two extremes but much nearer the solid than the plastic density. Dr. Muirhead concludes that the results are not favorable to Sir Wm. Thomson's (or Hopkins's) hypothesis, that while the earth was passing from a liquid to a solid state, cooled fragments of the earth's crust would have descended deeply toward the earth's interior, and built up a sort of irregular interior framework to support the at last successfully forming crust.*

Mr. Hannay observes that slags and even molten granite show the same phenomenon—the solid floating on the liquid; that from experiments he has made at blast furnaces on the Clyde, he has invariably found this to be the result, though he has not yet had an opportunity for making measurements.

3. *Climate of Siberia in the Era of the Mammoth.*—An excellent paper by HENRY H. HOWORTH, in the Geological Magazine for December, discusses the question as to the climate the ancient Mammoth and Rhinoceros had in Siberia. In earlier papers the author had presented the facts as to the distribution of these animals in that region; that the bones are few in Central Siberia, but increase in numbers toward and along the Arctic shores, the quantity being stated to be so great in the Bear Islands and the islands of New Siberia that "the ground is largely composed of the bones of Mammoths and the associated animals." In the last paper the author speaks of the unfitness of Northern Siberia for such life, the barren, frozen ground, even the most favored spots growing stunted willow bushes as almost the only vegetation, and green for not over two months in the year; and the vicinity of the Arctic coast where Mammoth bones abound, as a bare waste without trees or shrubs of any kind. He next shows, from the remains of plants associated with the bones in the beds containing them, as reported by investigators, that the flora of this same Northern Siberia in the Mammoth era contained species of *Picea*, *Abies*, *Larix* among Conifers, species of *Betula* (birch), *Salix* (willow), an *Alnaster* and *Ephedra*—plants now thriving in Southern Siberia; and the waters or land, as the fresh-water clays have in some places shown species of *Helix*, *Planorbis*, *Valvata*, *Limnæa*, *Cyclas*, *Anodonta*. Further, the deposits of trunks and branches of large trees (little altered) are very extensive, especially in the northern regions where the bones most abound, far beyond the reach of living trees of any size. In view of the facts, which are given with much interesting detail, the author concludes that the North Siberian climate in the era of the Mammoth was far more temperate than now; that the vegetation was much like that of Southern Siberia, the larch, willow and Alnaster being the prevailing trees; that probably Lithuania "where the Bison now survives, and where so many of the other contemporaries of the Mammoth still live, pre-

* Rep. Brit. Assoc. for 1876, Part II, p. 8.

sents to us a not unfaithful picture of what Northern Siberia must have been like from the Urals to Behring's Straits."

4. *The Climatic Changes of later Geological times: a discussion based on observations made in the Cordilleras of North America;* by J. D. WHITNEY. Memoirs of the Museum of Comparative Zoology at Harvard College. Vol. VII, No. 2. Part I. 120 pp. 4to. Cambridge, 1880.—This volume commences with a chapter on the glacial and surface geology of the Pacific Coast. It discusses the action of glaciers, argues that they cannot make lake basins, except through the inclosures its moraines may have formed, and attributes the erosion of glacier valleys chiefly to the running water. The glacial phenomena of the Sierra Nevada are described, and from these pages we cite a few of the facts. They are confined mostly to a belt three to four degrees wide, north of latitude 36°; but owing to declining height northward, they are less extensive north of the Tuolumne (37° 30′) than to the south. Along three rivers, the King's, the San Joaquin and the Tuolumne, the glacial masses were of great extent. That of the first had a length of fifty miles, and an area of 300 square miles. The glacial scratches are all over the region down to an altitude (as observed by Professor Brewer) of 4,000 feet, and nowhere below this. On the Joaquin, the glacier on the South Fork had a length of fifty miles, a depth, in some parts, of 1,500 feet, and a width in places of eight to nine miles. In the Tuolumne glacier region, the ice of the plateau region, 9,000 feet in elevation between the summit peaks, (Cathedral Peak, Mount Conness, Mount Dana and Mount Lyell), was over 1,000 feet thick. Below Soda Springs is the Cañon of the Tuolumne, having precipitous walls of rock 1,000 to 1,500 feet high, scored well by the glacier; but, as Professor Whitney holds, this gorge could not have been glacier made. The ice-marks reach down to about 3,650 feet above the sea-level. The glacier of the Merced is next described, and strong arguments are urged against the view that the Yosemite was made by glacier erosion. It is stated that the glacier of the Merced could not have extended as far as the Yosemite, and, consequently, the ice never entered that valley. Its walls bear no glacier-made markings. The glacial appearances of localities farther north are also treated of with many interesting details. In no part of the Sierra Nevada are they met with below a level of 2,000 feet above the sea.

The author also reviews the facts observed in the Rocky Mountains and to the north; and from the whole finds his former conclusion sustained, that no *northern* drift exists in any part of Western North America—not even in British Columbia; and he adds that Mr. Dall has reported the same to be true of Alaska.

"The desiccation of later geological times" is the subject of the closing chapter of the work. The facts are mentioned with regard to the former wide limits of existing lakes between the Sierra Nevada and the Front Range of the Rocky Mountains, and of many others now dried up, and others from other regions on the

western part of the continent; and the conclusion is reached that the cause of the great desiccation was climatological, and not a consequence of change of level.

5. *Six Lectures on Physical Geography;* by the Rev. SAMUEL HAUGHTON, F.R.S., M.D. Dubl. and D.C.L. Oxon.; Fellow of Trinity College, and Professor of Geology in the University of Dublin. 386 pp. 8vo. Dublin, 1880. (Longmans, Green & Co., London.)—Professor Haughton's mathematical studies connected with certain points in physical geography have been of much service to geology. The lectures here published with their appended notes bring out some of these points, as well as many generally accepted views, and discuss a few others of like geological interest. Even if the results are in some cases unsatisfying, owing to the use of insufficient data, the work is an important contribution to the science of terrestrial physics.

The *first* lecture presents some recent views as to "the past history and future prospects of the earth," involved in the assumed truth of the nebular hypothesis, and the recent inference of astronomers that the earth's day is slowly shortening.

The *second* treats of "continents and oceans, volcanoes and mountains." The heights of continents and depths of oceans are briefly reviewed, and a few general deductions brought out as to *axes* (following the meridians) *of elevation*, corresponding one to each continent, and *of depression*, one to each ocean, which axes are regarded as indicating the courses of the original wrinkles in the contracting globe. No note is taken, however, of the structure, age, true directions, or other details with respect to actual mountain ranges, or of the general courses of the earth's structure-lines.

The great east-and-west range of high land of Europasia, from the Pyrenees to the Himalayas, is spoken of as the most modern of mountain chains. But the Rocky Mountains also were raised 8,000 to 12,000 feet during the progress of the Tertiary (especially the Miocene and Pliocene), and the Andes in part to a greater height. The vast extent of these movements over the earth's continental surfaces during the Tertiary, when other large regions experienced little or no change of level is not considered. It is a good subject for contemplation and study by all physicists interested in terrestrial dynamics and the condition of the earth's interior.

Lecture III considers "the laws of climate and atmospheric and oceanic circulation." Heat from the earth's interior, and that from a cooling sun are here made the prominent sources of the earth's early climates. But the author returns to the subject in a note to the sixth lecture, many pages in length, in which he applies to the case of the earth's surface Rossetti's law of cooling. Professor Haughton, by this method, calculates the rate of cooling on the supposition that the source of heat is, *first*, sun-heat alone; *second*, earth-heat alone; and, *third*, variations in the thermal conditions of the earth's atmosphere; the other conditions in each

of these cases being supposed to be as they now are. The final "probable" conclusions thence reached are: that "the chief factor in changes of geological climate appears to have been the slow secular cooling of the sun;" that since life began on the globe, the earth's interior heat can not be regarded as "the sole and immediate cause of change of climate;" that the carbonic acid and moisture of the atmosphere have added to the warmth of past climates, the former chiefly during Paleozoic and earlier times.

He adds that the cold and precipitation of the Glacial era "was probably due to atmospheric changes caused by a temporarily diminished rate of heat-radiation from the sun."

The laws of modern climate also are discussed in the closing part of the third lecture, its main sources being made as usually understood, the sun's heat and aerial and oceanic circulation. In a note he introduces his calculations with regard to the total annual heat received at each point of the earth's surface, and on the amount of the loss of that heat caused by radiation into space; in which he finds that the whole amount of the sun's heat received is equivalent to that required to melt a layer of ice over the whole globe 80·5 feet thick, and that the part lost by radiation is equivalent to 28·5 feet of ice in thickness, leaving 51·5 feet, or more than 5-8ths of the whole, to be accounted for not as heat but as work.

The author, further, arrives at a parallel relation between the lengths of the geological ages as measured by the maximum thickness of sedimentary deposits, and by the rate of progress in its cooling climate. But, in the calculation, the Cambrian or Primordial era (in which Trilobites, Brachiopods and Worms were already in the seas) is united to the Azoic (Archæan), and thus it is made to antedate the epoch (of which he makes special use) when a mean Arctic temperature of 122° F. (that of the coagulation of albumen) was reached by the earth.

Moreover the calculations make the time between the era of the Miocene, with an Arctic mean temperature of 48° F., and the present to be longer than the preceding part of the Tertiary and all of Mesozoic time after the Triassic united (p. 93); or (as stated on p. 358, from other calculations) 41·7 per cent of the whole time of the possible existence of life on the globe at lat. 80° N.; a result widely at variance with the thickness of the sedimentary deposits of the eras, and also with the relative amount of physical and biological progress in the course of them. The idea of the extreme uniformitarian Professor Haughton rightly opposes, since it appears to have no sufficient support in geological facts. But that of regular gradation in declining temperature is in equal disagreement with the records. This is admitted by him for the Glacial era, whose cold is explained on the assumption of a temporarily lessened heat-radiation from the sun; and if this exception exists, there may have been, and probably were, many maxima and minima in the course of the progress.

It is probable, from recent discoveries, that the Arctic flora, referred to the Miocene by Heer, was actually Eocene; and if so, Professor Haughton's conclusion as to the length of after time would be more reasonable. But so many doubts invest the subject of geological time and rate of cooling that it would be premature to call any conclusion reasonable.

The remainder of the volume is occupied by Lectures IV and V, on the rivers and lakes of Europasia, Africa and America, in which the amount of water-discharge and detritus-transportation of a number of large rivers is estimated, and some conclusions deduced; and Lecture VI, on the Geographical Distribution of Animals and Plants, which treats also of the relations of species to climates with reference to geological questions, and assumes the existence of a once large and flourishing Antarctic Continent to help in explaining the origin of the resemblances which exist between the faunas of South America, Africa and Australia.

Many other topics, besides these here mentioned come under consideration in Professor Haughton's volume, making it a work of wide interest.

6. *Address by* H. C. Sorby, F.R.S., *President of the Geological Society of London, at the Anniversary meeting in February*, 1880. 60 pp. 8vo.—Mr. Sorby's presidential address is one of the most important of recent contributions to geological science. The author gives the result of a large amount of microscopic investigation into the condition and structure of the grains of non-calcareous stratified rocks, carried on in order to study out the true history or mode of origin of the rocks; and the rocks which are considered embrace fragmental rocks, from loose sand beds to consolidated sand-rocks and shales, metamorphic rocks, and slates as the passage way between the metamorphic and the preceding. The methods of distinguishing microscopically some of the more common minerals in slices and in sand, by the aid of polarized light, are also considered and elucidated by means of new researches. The development also of lamination, slaty structure and foliation, is among the subjects of investigation and receives new light. All the various topics are brought out in a brief way, and nothing short of the explanations given in the paper are sufficient to do them justice.

The following are a few of the results presented. From a study of sands from various sources the conclusion is arrived at that, excepting those which have been made by wind transportation, they generally bear little evidence of attrition, and often none. Even those of beaches, of river terraces, of the millstone grit of the coal-measures, and of most sand deposits, are often sharp-angled. Again, he shows that in what has been called crystallized sand or sandstone, the little quartz crystals which constitute it have sometimes been made by the deposition of silica about the grains; and that this is ordinarily, if not always, the mode of origin of a rock, whether friable or not, consisting of an aggregation of small or minute crystals of quartz. He instances the Devonian

Old Red Sandstone of Cockburnspath as affording examples, and mentions his finding them in deposits up to the Oölite. In remarks on the dependence of amount of wear on weight, Mr. Sorby observes that a grain one-tenth of an inch in diameter would probably be worn as much in drifting a mile as one one-thousandth of an inch in drifting 100 miles.

The lamination or fissile structure of shale, parallel with the bedding, he observes may be a result of mere pressure, the water of the original mud being thus squeezed out, and the thickness greatly reduced. In the case of slates from North Wales and other localities, he has found, by slicing and optical investigation, that they consist chiefly of microscopic scales which so closely resemble mica optically and in other ways, that they may be pronounced with good reason as of this species; and, since the scales lie mostly in the plane of bedding, a well cleaved slate of this type depolarizes like a uniaxial crystal having the principal axis perpendicular to the cleavage. When the mica scales conform thus in position to the plane of bedding in a slate, the author holds that they are probably of fragmental origin; since he has found in other slates in which the mica was "formed *in situ*, that the crystals of mica are not stratified but lie at all possible azimuths, and moreover are collected about special centers."

As an inference from the study of slates and other rocks, he says: "It appears to me that the development or absence of certain minerals in metamorphic rocks depended as much on the original nature of the material as on any mere difference of the temperature to which the rocks have been exposed; so that lower lying rocks might very well be less altered than those above them, even though probably at one time exposed to a higher temperature invading them from below."

Mr. Sorby has found that a gradual and perfect passage often exists "between an almost normal slate and what is practically a true mica schist," the only essential difference being in the difference in size of the crystals. Some fine-grained mica schists are further proved to be a result of the metamorphism of detrital beds by their containing isolated worn grains of quartz with the mica scales wrapped around them, and occasional grains of feldspar.

The proof that "the schists of the central Highlands of Scotland were originally slates" is worked out microscopically with great care, and the very probable conclusion is reached that "taking into consideration the character of both the feldspathic and quartzose grains," the material was to a considerable extent derived from a granite of a type very unlike that of Cornwall, but in some respects analogous to that of Aberdeen, though differing from it in being more like a quartz felsite."

These are a few of the deductions, in the Address, arrived at from the study of the least promising of all rock-formations—sand-beds and slates.

7. *Geological Survey of Pennsylvania.*—Great progress has been made toward the completion of the geological survey of

Pennsylvania, under its able director, Professor J. Peter Lesley. As recently announced by the Commissioner, forty-two counties of the State have been surveyed in full, eighteen surveyed in part, and only six remain untouched. The unfinished portion includes the eastern counties and some of the central. The publication of the results has gone forward as the work has advanced, and already eighteen reports on the geology of the several counties have been issued, besides sixteen special reports, and half as many more are in course of preparation. The field, and eminently that of Western and Central Pennsylvania, is one of vast mineral wealth, unexceeded in fact by any equal area on the continent, its coal, mineral oil and iron, yielding an annual income of 200 millions of dollars; and these are not the only valuable mineral products. And the surveys have had especial reference to all those points in the geological structure of the regions which should give more certainty to exploration and its results. They have been thorough geologically; and this means that they have gone to the bottom, so far as possible, both as regards scientific and economical questions, thoroughness comprising both classes of results. The yield of the three products just mentioned is so large, that any increase in the facilities or certainties of exploration, made by such a survey, even if producing a gain of only one per cent, is a vast increase in the aggregate amount of proceeds—sufficient to pay a hundred times over the whole cost of the survey.

Several of the reports have especially an economical bearing. A third report on the oil regions, by Mr. Carll, is the result of the last year's work, and will soon appear. Another, now in the press, treats of the waste in anthracite mining; it was prepared in response to a call from the legislature. The work on the area of the bituminous coal fields, being for the most part finished, the anthracite coal fields are now under careful study, and maps are in preparation showing not only the surface distribution but also the underground, at different depths, and the actual forms and extent as far as is possible, of the subterranean sheets of coal—work in which the geologists have great aid from the mining engineers. About twenty square miles, including the Wyoming region, were surveyed the past season, under Mr. Ashburner. The investigations seek to determine the actual thickness and course of the great mammoth vein, besides others, so that tunneling may be more certain in its results and safer from disaster. Besides maps, the work will include the making of a plaster model showing to the eye just how the great mammoth coal vein would look with all its flexures and irregularities, if the covering rock were lifted off—a method of exhibition first used many years since by Professor Lesley. Such investigations, besides aiding the miner, give a closely approximate idea of the amount of coal.

In a scientific way, also, the reports have great value. The "Keystone State" is eminently such geologically; and its survey is solving several problems for the country, besides giving us our best knowledge of its Coal-era vegetation.

The report of the Commissioner states that only three years more of work are needed to complete the survey; and it has been said rightly, that if continued and finished as proposed, it will be one of the most complete works of the kind ever accomplished, and will be worth to the State and its citizens many times its comparatively trifling cost.

The report of Mr. Ashburner on McKean County, including the Bradford oil-region, has been recently issued, and will be noticed in another number of this Journal.

8. *The Quaternary after the Era of the cave-animals in Europe.*—M. TARDY, in a paper in the Bulletin of the Geological Society of France for April 7, 1879, states that a bed of gravel, sands and clays, called *red diluvium* ("diluviums rouges"), occurs over a large part of France and the adjoining countries, covering the lœss and other deposits containing remains of the Cave-animals, Mammoth and in many places human remains or relics. It occurs near Paris and from there extends south. M. Hébert describes it about Bordeaux; and Casiano de Prado states that it overlies the stratified diluvium which contains bones of the *Elephas primigenius* and rolled pebbles, near Madrid, extending over the plateau of New Castille. Near Madrid it has an elevation of 660 meters; on the Col de l'Eremo, near Turin, 600 meters, and in France between Puy and Mende and between Mende and Saint-Flour, at a height of 800 meters. The fragments of the gravel are for the most part angular, and the beds show little stratification. The age to which this "red alluvium" is referred by Tardy is between the era of the mammoth and cave-animals (the equivalent of the Champlain period) and that of the neolithic beds or domesticated animals of Europe (or that of the early part of the modern period).

9. *River Channels filled with basalt and afterward cut out anew and deepened.*—Professor JOHN J. STEVENSON has described (Proc. Am. Phil. Soc., Aug., 1880) cases of re-eroded channel-ways on the Canadian and Mora Rivers, near Fort Union, in New Mexico. The original cañons of these rivers were cuts a thousand feet deep or so in the Dakota sandstone. At the mouth of the Mora (where the stream unites with the Canadian), the depth of the cañon before the inflow of basalt was 860 feet; the basalt filled up 470 feet of this depth; the waters, renewing the erosion process, cut a narrow way through the basalt, and below it to a depth of 230 feet. The cañon is now 1090 feet deep; but at a level 620 feet above the botton it is narrowed by a wide terrace, that of the top of the basalt. Mr. Stevenson's paper contains a section of the two streams two miles above their junction, showing similar features in the two as to the depth of the basalt and that of the new narrow channel cut through it into the subjacent sandstone. In other parts of the streams, the new channel follows the margin of the basalt. The basalt is that of a volcano seven miles east of Fort Union in the southern extremity of the Turkey Mountains. Entering the Mora cañon, the liquid rock flowed

onward to its mouth and, then, nearly three miles *up* the Canadian cañon. How far *down* this river was not ascertained.

The enormous extent of the erosion over the plains which preceded the time of the eruption of this basalt, the author attributes to an era of unusual precipitation that had then passed by.

10. *On the occurrence of* Proëtus longicaudus *Hall;* by H. S. Williams. (Communicated.)—The only specimen of this Trilobite of which published notice has been taken is, so far as I can ascertain, the one described by Professor Hall in the fifteenth Regents' Report, New York, 1862, p. 108–109, figs. 7, 8 and 9, Plate 10. The same specimen is figured in the "Illustration of Devonian Fossils," 1876, Plate xx, figs. 32–34, and the same notice is given of the specimen, so that we take for granted that in 1876 Professor Hall had seen only this specimen. The original specimen is said to have come from "far northeast of Des Moines, Iowa," and is regarded as from Hamilton rocks by Hall.

I have recently examined two more specimens of the same species, one a pygidium about the size of Hall's specimen, and the other a complete and nearly perfect specimen, but only about a third as large, folded up, and the pygidium protruding beyond the anterior margin of the glabella, as in the original specimen. They agree well with Hall's description and figure. The "nine" dorsal segments, the "twenty annulations on the axis of the pygidium," and the other details of the description are well carried out. Only about twenty of the annulations on the axis could be counted in the larger specimen, but there was still room for two or three more, which would be expected to appear in a larger specimen, or a perfect one. In the smaller specimen, they were too indistinct to count beyond fifteen or sixteen, but the proportion of those seen and their relations to the length of the axis leave little doubt of the perfect identity of these with the original form as described.

The specimens were sent for examination by Edwin Walters, Principal of the Madison Public Schools, Madison, Kansas. He writes that they were found in a blue limestone near Madison, Greenwood County, Kansas, and he describes the locality as "on the border of the Upper Carboniferous, the Permian and Cretaceous with an occasional indication of a Jurassic Age." From the reports of the Geology of Kansas it seems impossible to consider this locality as any lower than the Carboniferous, and if we regard it as Carboniferous the occurrence of the species here would not be inconsistent with the fact of the same species being found northeast of DesMoines, Iowa, where Carboniferous strata crop out, if one does not go too far into the corner of the State. Still, from what we know of the two localities, the Kansas rocks are more recent than those of northeastern Iowa.

Mr. Walters promises to make further examination, and a few associated fossils will fix with greater accuracy the horizon of this species. It certainly is one of the later representatives of its race, and may prove to be the last one known.

Cornell University, Ithaca, December, 1880.

11. *The Northern Sahara.*—Mr. G. Rolland has a paper on the Geology and Hydrology of the Northern Sahara (south of Algiers and Tunis between Biskra and El Goleah, 350 miles) in the Annales des Mines, 7th ser., xviii, 152, 1880. He describes the country as rocky, and states that Cretaceous strata, consisting of hard limestone, often dolomitic, constitute, in nearly horizontal beds, high plateaus, and are overlaid by the Quaternary. The Cretaceous formations recognized by the fossils, as near El Goleah and Mechgarden, are the Cenomanian and Turonian. The Quaternary deposits are coarse, but regularly stratified, and are of fresh-water origin. There are in places saline lagoons which were formerly more extensive, and this fact accounts, as M. Tournoüer has shown, for the occurrence of *Cardium edule* as a common shell along with fresh-water species.

12. *Arctic Coal.*—The mineral coal of Grinnell Land, near the winter quarters of H. M. S. Discovery, lat. 81° 43′ N. and long. 64° 4′ W., from beds whose overlying shales contain plants referred to the Miocene, afforded Mr. R. J. Moss (Proc. R. Dublin Soc., May, 1878), on analysis, Carbon 75·49, hydrogen 5·60, oxygen and nitrogen 9·89, sulphur (including 0·36 of S from pyrite) 0·52, ash 6·49, water 2·01=100. The composition is like that of much Carboniferous bituminous coal, which it resembles closely in luster. Sp. gr. = 1·3. The coal cakes when heated and affords 61 per cent of a coherent coke.

13. *The Claiborne Group and its remarkable fossils;* by Professor P. H. Mell, Jr., Auburn, Alabama. 10 pp. 8vo, 1880. (Trans. Amer. Inst. of Mining Engineers.)—The author of this paper can not be a geologist. In a section on page 5, stated to be "after Tuomey," he has the "Drift" put in, conformably, between the Coal-measures and the Cretaceous, which is certainly not after Tuomey; and the text referring to "the accompanying sketch" shows a like misapprehension of the facts. He says that there is only one locality of Zeuglodon remains in Alabama and devotes a paragraph to the explanation of this limited distribution, when it is not a fact. Again, speaking of the Tertiary, he remarks that "several strata displayed at Claiborne which contain but few fossils must have been deposited in a short space of time by the *great influx of ice-bearing sediment.*" Thus the Tertiary, as well as the Cretaceous, is badly mixed up with the Drift.

14. *Paleontology of Austria-Hungary.*—A new periodical in 4to, bearing the title "Beiträge zur Palaeontologie von Oesterreich-Ungarn," has been recently commenced under the editorship of E. v. Mojsisovics and M. Neumayr. The prospectus (dated May, 1880) states that about 200 pages and 30 plates are to be issued yearly, and that the annual subscription will be $10. All the prominent paleontologists of the Austrian empire have pledged their coöperation. Subscriptions should be sent to Mr. Alfred Hölder, 1 Rothenthurmstrasse, Vienna.

15. *A crystallized Mineral made from bricks at Blaenavon in Monmouthshire.*—J. Emerson Reynolds reports (Proc. R. Dub-

lin Soc., May, 1879), that in the oven of a Bessemer converter which was lined with ordinary siliceous fire-bricks, basic bricks were piled on the floor in contact with this lining; and that, after reaching an intense white heat, the pile or stack of basic brick subsided and (as was afterward discovered) its lower layers actually passed through the flooring leaving sharply cut outlines of their angles in the siliceous bricks. The refractory basic brick were made from an aluminous magnesian limestone. The resulting fused mass was partly in semi-transparent crystals of long prismatic form, either colorless or greenish, with sp. gr. = 2·934; and they afforded on analysis the formula of a lime-and-magnesia pyroxene—the results obtained being Silica 55·35, lime 23·24, magnesia 16·20, alumina and iron-sesquioxide 4·20, water, loss, etc. 1·01 = 100, corresponding, if the alumina and iron are set aside as impurity, to $(\frac{1}{2}Mg+\frac{1}{2}Ca)SiO_3$.

16. *Fossil Sponge-spicules from a clay bed in the Carboniferous strata near Sligo, Scotland;* by Professor H. J. Carter (Ann. Mag. Nat. Hist., V, xxxiii, 209).—Of the spicules here described, the most common is a sexradiate stellate kind, with 6 to 24 rays, according to the subdivisions of the arms, and having each ray spiriform—named by Carter *Holasterella Wrightii;* the other kinds are the hexactinellid, lithistid, and a sausage-shaped kind, like that of some of the *Renieræ* of the present day. *Holasterella conferta* has been found in a similar clay near Glasgow. Mr. Carter observes that "not only are the sponge-spicules, and the minute fossils of the Carboniferous limestone which accompany them, silicified and pitted on the surface with the same kind of rhomboidal excavations, but the "chert" to which Mr. Wright has alluded appears to be a solid pseudomorph of the limestone; for its pumice-like worm-eaten character occurring here and there, from partial absorption or decomposition of the material, presents a skeletal rhomboidal structure; while the same kind of rhomboidal excavations characterize the surface of the weather-worn *calcareous* fossils in the *pure Devonian limestone* of this neighborhood; by which I am led to infer that, in the first place, the sponge-spicules become partially or wholly calcified among *calcareous* material, else why should they now present rhomboidal excavations on their surface? that subsequently the siliceous element, being liberated, replaced the calcareous material so as to form the "chert;" and, thirdly, that the rhomboidal excavations on the surface of the spicules and the partial absorption of the spicules themselves, leaving nothing but their moulds, arises from the changes which the siliceous element itself is now undergoing—that is, becoming decomposed and removed, or passing from an amorphous state into clear quartz prisms."

17. *Glaciation of the Shetland Isles and the Orkneys.*—This subject has been well studied by Messrs. B. N. Peach and J. Horne. A paper by them on the Shetland Isles, published in the Quarterly Journal of the Geological Society for 1879, is referred to on page 72 of the last volume of this Journal; and another, on

the Orkney Islands, has since appeared in the Quarterly Journal for 1880 (pp. 648–663). In the former it was shown, from the striated surfaces and other evidence, that the region of the Shetland Isles had been glaciated by Scandinavian ice; and in the latter also the agency of the Scandinavian ice-movement is recognized; and the course of movement in both regions was mostly between W.N.W. and N.N.W. But while the Scandinavian glacier-mass was concerned in the great movement over both regions, in the case of the Orkneys, which are near Northern Scotland, the ice glaciating them came mainly, if not wholly, from Northeastern Scotland. This is apparent from the fragments of Scottish rocks, some of them fossiliferous, in the Orkney drift. The glacier of Northern Scotland descended northeastward over the west part of the North Sea, and there joined the great Scandinavian mass moving northwestward, in the direction of least resistance. The authors state that there is no evidence of marine drift deposits on the islands; and the absence of marine shells from the bowlder-clay is thought to "probably indicate that a portion of the present sea-floor round Shetland formed dry land during the climax of glacial cold." The facts are stated to confirm the views advocated by Dr. Croll more than ten years since. Two maps illustrate the recent article, one showing the striations of the Orkneys, and the other, the "probable path of the ice," from Scandinavia and Scotland over the islands named, and beyond to the margin of the deep-water trough of the ocean.

18. *Queensland Geology.* Report on the Geology and Mineral Resources of the district between Charters Towers Goldfields and the Coast; by R. L. Jack, F.G.S., Geological Surveyor Northern Queensland. Brisbane, 1879.

19. *Mineral discoveries in Alexander County, North Carolina.* —Mr. W. E. Hidden, who has been engaged for some time past in active mineral exploration in Western North Carolina, gives the following notes in regard to minerals found in Alexander County.—Beryl occurs in green, yellow, bluish and sometimes colorless crystals. The crystals are well terminated and often highly modified, resembling those from Siberia; they are generally implanted in cavities. A few fine crystals of a light chrome-green have been found loose in the soil on the Warren plantation. Spodumene is found on the Warren and Lyon plantations in small transparent crystals of a beautiful green color, associated with rutile, beryl, orthoclase and pyrite in a narrow vein. This variety of spodumene has been called Hiddenite by Dr. Smith (see p. 128). Rutile is found in brilliant crystals, often geniculated, transparent and of a beautiful deep red color. The best from Milholland's mill and R. Johnson's. Monazite in small splendent crystals occurs with rutile at Milholland's mill. Quartz occurs at many localities and in great variety of form and color, some of the crystals very beautiful. They are often highly complex, and rank with the most interesting of those from Switzerland. Many of the crystals enclose other minerals, such as chlorite, asbestus,

rutile, tourmaline, spodumene, and siderite. Other crystals contain fluid cavities. ORTHOCLASE occurs in large well-formed crystals (one weighed 40 lbs.) on the Price and Keever lands in a coarse granitic vein, associated with beryl, tourmaline, columbite, autunite, mica. TOURMALINE in fine brown-black crystals are found in the Price mine, also brilliant black crystals at B. Lyon's. In addition to the minerals already named, graphite, sphene, magnetite also occur in the county.

20. *Analysis of Jarosite from the Vulture mine, Arizona;* by S.F.PENFIELD. (Communicated).—The occurrence of jarosite with gold in the Vulture mine, Arizona, has been mentioned by Prof. B. Silliman (this Journal, xviii, 73, 1879). The variety analyzed is found in minute transparent crystals of a brownish-yellow color. It forms a frosted coating on cellular quartz, giving to the specimen a somewhat rusty look; under the microscope, however, the coating is resolved into distinct individual crystals, delicately grouped together. The crystals are tabular in habit, being a combination of the basal and rhombohedral planes; the angle of $O \wedge R$ was measured approximately and the result agreed with that already accepted ($124\frac{1}{2}°$).

The mineral is slightly soluble in water, the solution giving a reaction for sulphuric acid but not for iron. An analysis on material free from impurity except a little quartz, gave:—

	SO_3	Fe_2O_3	K_2O	Na_2O	H_2O	Quartz.
Sp. gravity=3·09.	30·42	48·27	8·53	0·28	12·91	1·08=101·49

The calculated ratio for $SO_3 : Fe_2O_3 : K_2O(Na_2O) : H_2O = 4 : 3·18 : 0·99 : 7·55$.

The water determination is probably slightly in error; if the amount be determined by difference (=11·42), the result differs but little from the ratio required by the formula $K_2SO_4 + Fe_2S_3O_{12} + 2H_6Fe_2O_6$.

21. *Jarosite from Colorado.*—Dr. G. A. KÖNIG has recently described jarosite from the Iron Arrow Mine, Chaffee Co., Colorado. It occurs in seams and cavities in a siliceous turgite and hematite. It is found in minute brilliant crystals (R with O) isolated, also in groups and in crystalline crusts. The crystals are transparent, varying in color from a light amber-yellow to dark brown; the luster on the faces is adamantine, on the fracture resinous. Specific gravity =3·144. An analysis afforded

SO_3	Fe_2O_3	K_2O	Na_2O	H_2O	SiO_2	
28·57	51·10	7·13	0·84	10·56	2·40	=100·80

Rejecting the silica as an impurity, also 8·7 p. c. turgite ($Fe_4H_2O_7$), the remainder is found to correspond to 89·6 p. c. of jarosite ($K_2Fe_6S_4O_{22} + 6aq = K_2SO_4 + Fe_2S_3O_{12} + 2H_6Fe_2O_6$) with ·4 p. c. water in excess.—*Proc. Acad. Nat. Sci. Philad.*, 1880, p. 331.

22. *Octahedrite from Burke County, North Carolina;* by W. E. HIDDEN (from a letter dated Stony Point, N. C., Dec. 17, 1880). —This rare mineral was found by the writer in the auriferous gravels of Brindletown in the summer of 1879. Subsequent search in the vicinity has proved its distribution through all the

gold placers of the surrounding country. Its best locality is on the northern slope of the Pilot Mountain, especially at the mine of Capt. J. C. Mills.

The crystals are commonly tabular in form, consisting of the planes 1 and *O*, though crystals have also been observed of the common octahedral habit. Some few were highly modified. The planes are as a rule splendent excepting the basal plane which is dull and striated parallel to 1 and 1-*i*. The prismatic (*I*) cleavage can often be seen. The crystals are well preserved and unusually large, some measuring one-third of an inch across; they average a line in thickness. Color from greenish-yellow to black. Some few are quite *colorless* and *transparent* and would admit of polariscopic examination. In only one case were they found implanted and that was on quartz. They occur loose in the gravel, having been derived from the disintegration of the local schists. The accompanying minerals are monazite, xenotime, fergusonite, samarskite, zircon, brookite and thirty-five other distinct mineral species.

23. *On Urano-thorite.*—Professor Peter Collier has described a mineral from the Champlain iron region (exact locality unknown), which is closely related to thorite (orangite), but differs in containing considerably more uranium. It has a dark red-brown color, a resinous or sub-vitreous luster, yellow-brown streak and sub-conchoidal fracture. Hardness about 5; specific gravity =4·126. It is infusible before the blowpipe. An analysis yielded:—

SiO_2	ThO_2	U_2O_3	Fe_2O_3	Al_2O_3	PbO	CaO	MgO	Na_2O	H_2O	
19·38	52·07	9·96	4·01	0·33	0·40	2·34	0·04	0·11	11·31	=99·95

The name given to the mineral has reference to the large amount of uranium present; thorite contains 1·6 p. c., according to Berzelius.—*Journal Amer. Chem. Soc.*, vol. ii.

24. *Mineralojia* por Ignacio Domeyko, Profesor de Quimica i Mineralojia en la Universidad de Santiago de Chile. Third edition. 762 pp. with 6 plates. Santiago, 1879.—The preceding edition (2d) of the valuable Mineralogy of Prof. Domeyko was issued in 1860. Since that time he has published five Appendixes to this work, in addition to numerous articles printed in different scientific journals. It is consequently a great convenience to mineralogists to have this new edition, in which the large number of new facts, due mostly to labors of the author himself, are incorporated. The minerals of Chili and the neighboring republics are in many cases of peculiar interest, and for our knowledge of them we are indebted almost entirely to Professor Domeyko, whose unwearying and most successful activity in investigation, far removed as he is from the scientific centers of the world, is worthy of high praise.

25. *Las Especies Minerales de la Republica Argentina* por el Dr. D. Luis Brackebusch. 117 pp. 8vo. Buenos Aires, 1879. —Dr. Brackebusch has rendered an important service to science in publishing in compact form a description of the minerals of the

Argentine Republic. Under each name is given a description of the species, and a full list of localities with the associated minerals at each. The fact that much of the matter has either not been published before, or, if at all, in periodicals not generally accessible, makes the book a valuable one to all interested in mineralogy, and gives it more than a local interest.

26. *Zoology for High Schools and Colleges;* by A. S. PACKARD, JR. Second edition, revised. New York: Henry Holt & Co. 1880.—In this edition, many improvements have been introduced, and some errors contained in the first edition have been corrected. The objectionable figures of the brains of fishes and of the anatomy of the cat have been replaced by new and better figures, drawn by Dr. C. S. Minot. The total number of cuts is 475, most of which fairly represent the objects for which they were intended, but there are still remaining some that were very badly engraved and others that were evidently badly drawn, and which might well have shared the fate of those that have been discarded. V.

III. ASTRONOMY.

1. *On the Figure of the Planet Mars and its accordance with the hypothesis of the former fluidity of the planet;* by Professor HENNESSY, (C. Rend., June, 1880).—Professor Hennessy here gives a calculation of the polar depression in Mars, supposing it to have been a result of rotation during a condition of fluidity. Assuming that the mass is distributed in spheroids of equal density, the density increasing from the surface to the center, and that the ellipticity depends on this law and the period of rotation of the planet, he arrives at the value

$$e = \frac{1}{227{\cdot}61}$$

which he says is very near the result obtained in the careful observations of Professor C. A. Young,* namely,

$$e = \frac{1}{219}.$$

Professor Hennessy also calculates the polar depression supposing it to be a result of erosion by a liquid moving over the surface of the planet, and obtains

$$e' = \frac{1}{179{\cdot}24},$$

which he observes is sensibly larger than the results of the best measurements. He states, therefore, that Young's result much better accords with the hypothesis of the former fluidity of the planet than with that of a shaping by erosion; and that this corresponds with the parallel fact as regards the earth.

* This Journal, xviii, 206, March, 1880.

IV. Miscellaneous Scientific Intelligence.

1. *Ocean temperatures in the Arctic— Observations taken on the S. S. Gulnare, by* O. T. Sherman.—The following observations were taken on the Arctic S. S. Gulnare, during the summer of 1880. A Miller-Cassella thermometer was employed; its scale errors, carefully obtained, have in each case been applied. The steamer, at the time of making the observations, lay becalmed. If we refer to the older maps we see that on some the warm waters which render the west coast of Greenland habitable are connected with the Arctic current which renders the east coast barren. On others the warm current is shown at once as a branch of the Gulf Stream. On the newer German maps the currents are shown overlapping in about latitude 61° N. The following table serves to give confirmation to this latter representation, and also indicates the limits and depth.

Table I.—*Deep Sea Temperatures.*

Depth in fathoms.	Lat. 60° 6′ N. Long. 56° 36′ W.	Lat. 57° 33′ N. Long. 55° 15′ W.
0	41°·9 F.	45°·0 F.
10	41·8	----
20	40·0	----
30	----	45·0
60	39·0	40·0
90	----	39·0
110	38·8	----
150	38·2	40·0
270	40·8	----
300	40·8	----

The sudden rise in temperature at the lowest depths naturally caused some surprise to the observer, and was therefore measured three times. These observations may also in part explain the bend in the curve representing the limit of ice.

Phenomena of some rarity in the surface temperatures and densities were also observed by us. When passing in front of a glacier outlet, or across the track of the ice pack, we suddenly entered a body of water much colder and fresher than that surrounding it. The ice in each case readily suggested an explanation. Our interest was more excited at the depth of the freshened water, for the engineer found independently the same changes of density in the water he took into the boiler about ten feet below the surface. On one occasion we had to sink a thermometer ten fathoms before obtaining indications of a rise in temperature.

It is true that the outcropping of the Arctic current would give similar phenomena, but to one on the spot the change was always seen to be connected with the melting of the ice.

TABLE II.—August 4, 1880.

Position.	Hour.	Surface Temperature.	Density Hydrometer, scale reading.	Remarks
	5	44·°0	4°·0=1·027316	
	6	46·0	4·0=1·027383	
	7	46·0	4·0=1·027383	
	8	35·5	2·5=1·016492	A deep-sea thermometer sank 10 fathoms, read 40°·0.
	9	36·0	2·8=1·018644	
	--	----	----------	
Cape Desolation sighted abeam,	10	39·5	3·0=1·020064	
	11	36·0	2·8=1·018644	
	12	36·0	3·2=1·021521	
	1	37·0	2·8=1·018527	
	2	42·0	2·8=1·018652	
	3	42·0	3·0=1·020091	
	4	43·0	3·0=1·020107	
		August 5, 1880.		
	2	44·°	3·0=1·020122	
Latitude 61° 27′.	3	44·	3·0=1·020122	
	4	36·	2·5=1·016486	Opposite glacier, about 30 miles off shore.
	5	37·	3·0=1·020068	
	7	37·8	2·8=1·018508	
Lat. 63° N., long. 51°,		Aug. 6, 1880.		
	4	38·0	4·0=1·027246	
	5	37·5	4·0=1·027240	
	6	38·0	4·0=1·027246	

2. *International Exposition of Electricity, under the patronage of the French Government at Paris, in* 1881.—An International Exposition for the conference of electricians and the exhibition of all kinds of electrical apparatus, practical and theoretical, will be opened at Paris on the 1st of August next, and closed on the 15th of November. The exposition is put under the department of the Minister of the Post Office and Telegraphy, M. AD. COCHERY, and under the special superintendence of M. GEORGES BERGER as Commissary General. The *Palais des Champs Elysées* is assigned for the exhibition. Announcements as to the apparatus and materials to be put on exhibition by individuals, and as to the space desired, should be made to the Commissary General by the 31st of March, who will send forms for their admission on being applied to, and special labels for packages, and will notify contributors by the 15th of May with respect to the space allotted them. Packages will be received at the grounds of the Palais des Champs Elysées on and after July 1st. They should be addressed *Commissaire Général de l'Exposition internationale d'Electricité, au Palais des Champs Elysées, porte No. IV.* No charge will be made for the space given. Motive power will be furnished at a low price to such as desire it, but without charge for all necessary experiments. The articles for exhibition will comprise:

Apparatus for the production and transmission of electricity. Native and artificial magnets and magnetic needles. Apparatus for the study of electricity.

Apparatus for its various applications; for telegraphy and the

transmission of sound; for the production of heat; for illumination and uses in light-houses and signals; for mines, railroads and navigation; for military purposes; for the fine arts; in galvanoplasty, electro-chemistry and the chemical arts; for the production and transmission of motive power; in horology; in medicine and surgery; in astronomy, meteorology and geodesy; in agriculture; for registering purposes; for working various kinds of industrial machines, and for domestic uses.

Lightning rods. Collections of apparatus illustrating the history of the subject and its applications from the earliest times. Collections of books and memoirs pertaining to the science and to electrical industry.

In connection with the exposition, an International Congress of Electricians will be opened on the 15th of September, under the presidency of Minister AD. COCHERY.

3. *A History of the Jetties at the Mouth of the Mississippi River;* by E. L. CORTHELL, C.E., Chief Assistant and resident Engineer during their construction. 383 pp. 8vo, with numerous plates and maps. New York: 1880. (John Wiley & Sons).—This volume gives a detailed history of the construction of the Mississippi jetties by Mr. James B. Eads, from the time when this plan was first proposed until its final completion. The account is written in popular style, and will be read with interest even by those who have no knowledge of the scientific problems involved in the work. The excellence of the scheme as a whole has been proved by the success finally attained, and the perseverance and enterprise with which it was carried forward in the face of discouragements and difficulties of all kinds are deserving of high commendation. The position of Mr. Corthell as chief assistant and resident engineer has given him a minute and personal knowledge of the many details in the progress of construction of the jetties, and much of the interest of the book is due to this fact. Numerous charts and plates show among other things the successive steps in progress of the work, and the corresponding results attained in the deepening of the river channel. A portrait of Mr. Eads, to whom the success of the plan is most of all due, forms a frontispiece to the volume.

OBITUARY.

An announcement of the death of M. CHASLES appeared in the January number of this Journal. It occurred on the 18th of December last, in his 88th year, he having been born on the 15th of November, 1793. It is nearly seventy years since the first publication of the distinguished geometer appeared in Hachette's Correspondence; and his scientific activity has continued into the last year of his long life.

The larger works of M. Chasles are five in number: *Aperçu Historique sur l' Origine et le Développement des Méthodes en Géométrie, Traité de Géométrie Supérieure, Traité des Sections Coniques, Les trois livres des Porismes d'Euclid,* and *Rapport sur*

le Progrès de la Géométrie en France. Besides these, however, there are between two and three hundred of his memoirs in the Academic publications and scientific journals.

His demonstrations were remarkable for their neatness and perfection of form. In geometry this quality is all important. Shortly after his appointment as Professor of Higher Geometry in the Faculty of Sciences at Paris, he published his *Traité de Géométrie Supérieure.* This was some years later followed by his *Traité des Sections Coniques.* In these volumes, as well as in his memoirs, M. Chasles uses in his demonstrations, three conceptions in addition to those of Euclid, *the anharmonic function of four points, homographic divisions,* and *involution of six points.* By these conceptions he introduces many of the advantages of analytic geometry into what will probably still be regarded as synthetic geometry. If asked what is the real addition thus made to Euclid we might answer: 1st, the conception of plus and minus segments of lines, and, 2d, the use implicitly of the relations of the roots and coefficients of the equation of the second degree. That is, he added to synthetic geometry the resources of the algebra of simple and quadratic equations. With the skill of a master he wrought into formal and logical connection the theorems that have enriched geometry in these later years, adding everywhere new propositions and new chapters of his own to the science.

Rarely has there lived a man more steadfast in his devotion to one object through life, more simple in character and aims, more charming in social intercourse, more honored and beloved by all who had the good fortune to know him. H. A. N.

First Annual Report of the Department of Statistics and Geology of the State of Indiana. 514 pp. 8vo, Indianapolis, 1879. Devoted to State Statistics, Agricultural, Social, Vital, etc.

Annual Report of the Curator of the Museum of Comparative Zoology at Harvard College to the President and Fellows of Harvard College for 1879–80.

Thirty-fifth Annual Report of the Director of the Astronomical Observatory of Harvard College; presented to the Visiting Committee, December 6, 1880, by Edward C. Pickering.

James Smithson and his Bequest, by William J. Rhees. 159 pp. 8vo, Washington, 1880. (Smithsonian Miscellaneous Collections, 330). This volume contains a sketch of the life of James Smithson, a list of his writings, notices of his death and tributes to his memory; it also gives a statement in regard to the founding of the Smithsonian Institution by his bequest.

Introduction to the Study of Indian Languages with words, phrases and sentences, to be collected by J. W. Powell. 4to, with several charts. Washington, 1880. This volume is intended to aid those engaged in collecting linguistic and ethnographic facts from the Indian tribes. After a chapter on the alphabet, and another of "hints and explanations," occupying together about 76 pages, there are 150 pages of schedules, for use in taking notes, containing, in a marginal column, lists of objects and sentences, with broad blank columns for the corresponding Indian terms and additional remarks.

APPENDIX.

ART. XIX.—*Principal Characters of American Jurassic Dinosaurs;* by O. C. MARSH. Part IV. *Spinal Cord, Pelvis, and Limbs of Stegosaurus.* With three Plates.

IN a previous article,* the writer brought together the more important facts then known in regard to the *Stegosauria*, one of the most singular groups of extinct reptiles hitherto discovered. In the present communication some additional characters of these animals are recorded, even more remarkable than those previously brought to light.

THE BRAIN AND SPINAL CORD.

In the article cited above the brain-cast of *Stegosaurus ungulatus* was described and figured, and it was shown that this reptile had the smallest brain of any known land vertebrate. The general form and comparative size of the brain in this reptile is represented in Plate VI, figures 1 and 2.

During a subsequent investigation of another individual of the same genus, the writer found a very large chamber in the sacrum, formed by an enlargement of the spinal canal. This chamber was ovate in form, and strongly resembled the brain case in the skull, although very much larger, being at least ten times the size of the cavity which contained the brain. This remarkable feature led to the examination of the sacra of several other individuals of *Stegosaurus*, and it was found that all had a similar large chamber in the same position. The form and proportions of this cavity are indicated in Plate VI, figures 3 and 4, which represent a cast of the entire neural canal enclosed in the sacrum. The large vaulted chamber, it will be observed, is mainly contained in the first and second sacral vertebræ, although the canal is considerably enlarged behind this cavity. The sections represented in figure 5 are in each case made where the transverse diameters are greatest.

* This Journal, vol. xix, p. 253, March, 1880.

The remarkable feature about this posterior brain-case, if so it may be called, is its size, in comparison with that of the true brain of the animal, and in this respect it is entirely without a parallel. A perceptible swelling in the spinal cord of various recent animals has indeed been observed in the pectoral and pelvic regions, where the nerves are given off for the anterior and posterior limbs; and in extinct forms some very noticeable cases are recorded, especially in Dinosaurs, but nothing that approaches the sacral enlargement in *Stegosaurus* has hitherto been known. The explanation may doubtless in part be found in the great development of the posterior limbs in this genus; but in some allied forms, *Camptonotus* for example, where the disproportion between the fore and hind limbs is nearly as marked, the sacral enlargement of the spinal cord is not one-fourth as great as in *Stegosaurus*.

It is an interesting fact then in young individuals of *Stegosaurus* the sacral cavity is proportionately larger than in adults, which corresponds to a well known law of brain growth.

The physiological effects of a posterior nervous center, so many times larger than the brain itself is a suggestive subject, which need not here be discussed. It is evident, however, that in an animal so endowed, the posterior part was dominant.*

The Pelvic Arch.

The true sacrum of *Stegosaurus* is composed of four well coössified vertebræ. In fully adult animals the pelvic arch may be strengthened by the addition of one or more lumbar vertebræ, as in the specimen figured in Plate VII, where two are firmly consolidated with the sacrum. The centra of the sacral vertebræ are solid, like the others in the column. Their neural arches are especially massive, and the spines have high and expanded summits. The transverse processes of the sacral vertebræ are stout vertical plates, which curve downward below, and unite to meet the ilia. Each vertebra supports its own process, although there is a tendency to overlap in front. There is a gradual increase in size from the first to the last sacral vertebra, and the first caudal is larger than the last sacral.

The ilium in *Stegosaurus* is a very peculiar bone, unlike any hitherto known in the Reptiles. Its most prominent feature is its great anterior extension in front of the acetabulum. Another striking character is seen in its superior crest, which curves inward, and firmly unites with the neural arches of the sacrum, thus roofing over the cavities between the transverse processes. The acetabular portion of the ilium is large and

* The main facts here presented were communicated to the National Academy of Sciences, in a paper read at the New York meeting in November last.

shallow (Plate VII, figure 1, *ac.*) The face for union with the ischium is large and rugose, but that for the pubis is much less distinct. The post-acetabular part of the ilium is very short, scarcely one-third as long as the anterior projection.

The ischium of *Stegosaurus ungulatus* was figured and described in the communication already cited. It is short and robust, and has a prominent elevation on the upper margin of the shaft (Plate VIII, figure 2). Its larger articular face meets a post-acetabular process of the ilium, and a smaller articulation joins the pubis. The shaft of the ischium is twisted so that it resembles somewhat the corresponding bone of *Morosaurus.*

The pubic element of the pelvis of *Stegosaurus ungulatus* is in general form somewhat like that of *Camptonotus.* The true pubis consists of a strong spatulate process, projecting forward nearly horizontally. (Plate VIII, figure 2, *p.*) Its proximal end articulates with the pre-acetabular process of the ilium. The post-pubic branch extends backward and downward, nearly to the end of the ischium. The two bones fit closely together in this region. The usual pubic foramen is in this species replaced by a notch, opening into the acetabular cavity. In a smaller undescribed species, which may be called *Stegosaurus affinis,* the post-pubic bone is slender and more rod-like, not flattened, as in the specimen here figured.

The Hind Limb.

The large bones of the leg of *Stegosaurus ungulatus* have already been figured, and their main characters described. The femur is remarkably long, and without a third trochanter. The tibia, on the other hand, is very short. When the animal stood at rest, these two bones of the leg were nearly in the same line, as shown in Plate VIII, figure 2. The fibula is slender, and has its larger end below.

The astragalus is firmly coössified with the tibia, and the calcaneum is also united, but less securely. There are three bones in the distal row of tarsals. (Plate VIII, figure 2.) The one on the inner side is massive, and semi-circular in transverse outline. The median tarsal is still larger, while the outer one is quite small. There are five well developed metatarsals, which are of moderate length, and robust proportions. The first digit is terminated by a strong, broad, ungual phalanx, the largest of the series. The second, third and fourth digits also have similar phalanges of smaller size. The outer digit has only a tubercle at its extremity. The number of phalanges in the fourth and fifth digits has not been exactly determined, but they were less than the usual number.

The Fore Limb.

The principal bones in the scapular arch and fore leg of *Stegosaurus* were described and figured in the article already cited. In Plate VIII, figure 1, these are brought together, and the fore foot added in its natural position. The humerus and bones of the fore arm show clearly that this limb, although very small in proportion to the hind leg, was very powerful, and as it admitted of considerable rotation, it was doubtless used mainly for other purposes than locomotion. The foot here represented was found by the writer, with the bones nearly in the position indicated. There are only three carpal bones in the proximal series, and in this foot the distal segment of the carpus remained unossified. There are five digits, the fifth being the smallest.

The great disproportion in size between the fore and hind limbs, as well as the structure of the principal joints in each, show plainly that *Stegosaurus* walked mainly as a biped. The massive posterior limbs, and the huge tail doubtless formed a tripod on which the animal rested at times, while the fore limbs were used for prehension, or defense. The heavy dermal plates and powerful spines probably rendered the latter an easy task.

Yale College, New Haven, Jan. 24th, 1881.

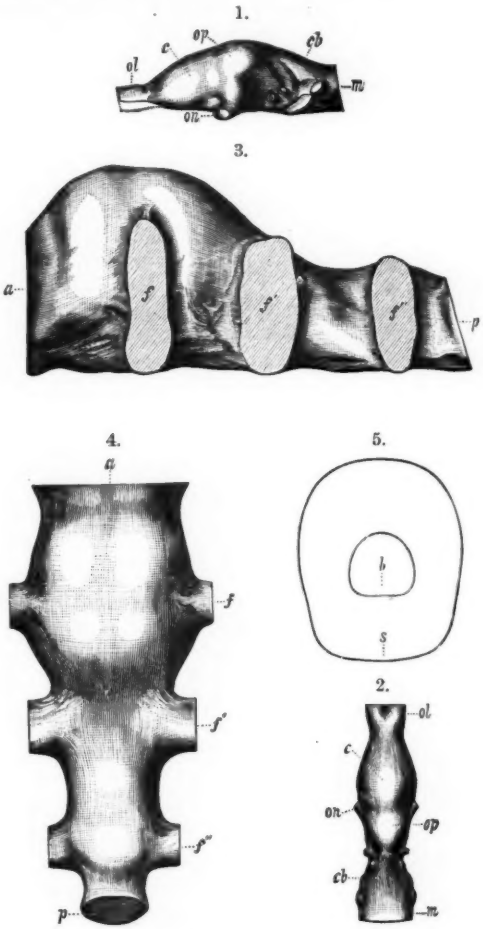


Figure 1.—Brain-cast of *Stegosaurus ungulatus*, Marsh, side view; *ol*, olfactory lobes; *c*, cerebral hemispheres; *op*, optic lobes; *on*, optic nerve; *cb*, cerebellum; *m*, medulla.

Figure 2.—Same brain-cast, seen from above.

Figure 3.—Cast of neural cavity in sacrum of *Stegosaurus ungulatus;* side view; *a*, anterior end; *f*, foramen between first and second vertebræ; *f'*, same between second and third vertebræ; *f''*, same between third and last vertebræ; *p*, exit of neural canal in last sacral vertebra.

Figure 4.—Same cast, seen from above.

Figure 5.—Outlines representing transverse sections through same brain, and sacral cavity; *b*, brain; *s*, sacral cavity.

All the figures are one-fourth natural size.

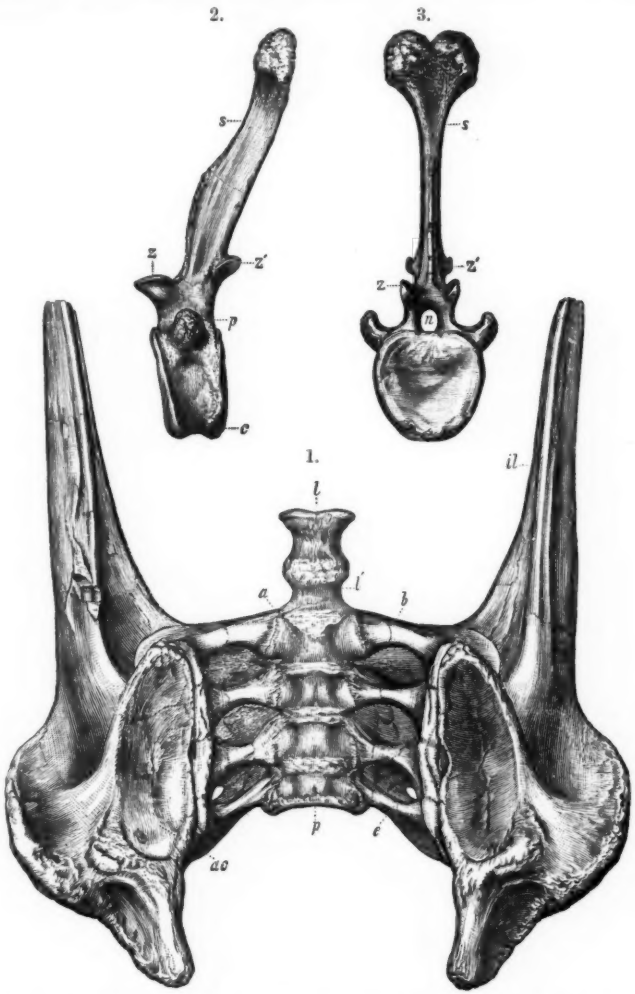


Figure 1.—Sacrum and ilia of *Stegosaurus ungulatus*, Marsh, seen from below. One-twelfth natural size. *a*, first sacral vertebra; *b*, transverse process of same; *p*, last sacral vertebra; *c*, transverse process of same; *l*, second lumbar vertebra from sacrum; *l'*, lumbar vertebra next to sacrum; *il*, ilium; *ac*, acetabulum.

Figure 2.—Anterior caudal vertebra of *Stegosaurus ungulatus*, side view; one-eighth natural size.

Figure 3.—Same vertebra, front view; *s*, neural spine; *z*, anterior zygapophysis; *z'*, posterior zygapophysis; *p*, transverse process; *n*, neural canal; *c*, face for chevron.

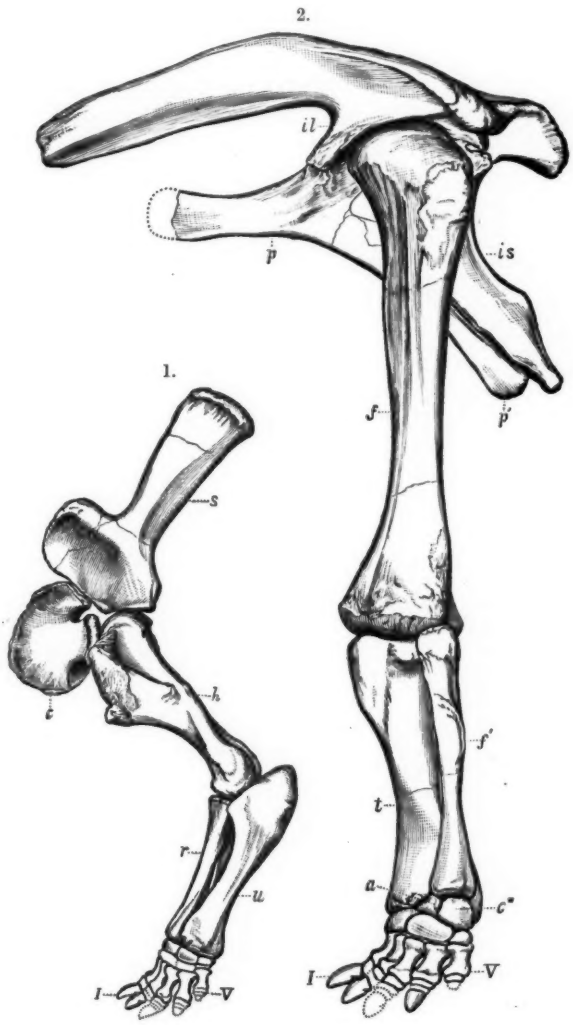


Figure 1.—Bones of left fore leg of *Stegosaurus ungulatus*, Marsh; *s*, scapula; *c*, coracoid; *h*, humerus; *r*, radius; *u*, ulna; *I*, first digit; *V*, fifth digit.
Figure 2.—Bones of left hind leg of *Stegosaurus ungulatus*; *il*, ilium; *is*, ischium; *p*, pubis; *p'*, postpubis; *f*, femur; *t*, tibia; *f'*, fibula; *a*, astragalus; *c*, calcaneum; *I*, first digit; *V*, fifth digit.
Both figures are one-sixteenth natural size.